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The responsibility for the statements and opinions in the following papers and discussions rests with the individual authors and speakers; the Society merely places them on record.

Owing to financial exigencies, certain usual features of this volume have been omitted. It is hoped to remedy this in succeeding volumes.

The Royal Society of Tasmania

Papers and Proceedings, 1933

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Papers
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The Royal Society of Tasmania
1933

THE TROUT-FOOD INSECTS OF TASMANIA.

PART I.—A STUDY OF THE GENOTYPE OF THE MAYFLY GENUS ATALOPHLEBIA AND ITS LIFE HISTORY.

By

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Plates I. and II.

(Read 8th May, 1933.)

INTRODUCTION.

The study of the more important insects which serve as food for trout in any given country is, in these days of applied science, an indispensable preliminary to a full understanding of the methods by which a successful and permanent trout-fishery can be maintained in that country. For many years I have been interested in those groups of aquatic insects which are of most importance as trout-food. But I have never found, anywhere in Australia, any public realisation of their economic importance, and thus it comes about that, even to-day, when scientific ideas have penetrated further into the public mind than ever before, it still remains impossible for any work on such insects to be carried out officially. The alternatives are, either to leave the subject alone and let the knowledge gained die with one, or to work at the subject slowly in one's spare time, in the hope that something of value may come out of it in time to save the inland fisheries of Australia from deterioration due to lack of scientific knowledge.

It is my considered opinion that the time has now come when it is imperative that a scientific survey of the trout-food insects should be carried out in all the principal trout-fishing districts of the Commonwealth. These are to be found in New South Wales, Federal Capital Territory, Victoria,

and Tasmania. From a faunal point of view, the first three are closely united, and might well be studied as a single unit, though the number and variety of the streams included would make a thorough survey a lengthy and difficult task. Tasmania, however, needs to be studied separately, not only because it is an island, possessing marked peculiarities in its aquatic fauna, but also because, in Tasmania alone, of any part of the Commonwealth, there are present fresh-water lakes suitable for trout-fishing and, in many ways, superior to the rivers.

The present paper is planned to be the first of a series to be written for the Royal Society of Tasmania, dealing with the Trout-food Insects of that State. As the Order Plectoptera, or Mayflies, is the most important order of insects considered as trout-food, I propose to deal with them first, leaving the other aquatic orders for later treatment.

When one comes to study the Mayflies of Tasmania, one is met with the remarkable fact that only two species have so far been described from that island, and that one of these has not been recognised since it was last dealt with by Eaton (1884), nor does it appear ever to have been collected again since its original capture by Dr. Hooker in 1842! As this species was designated as the genotype of the genus *Atalophlebia* (Eaton), by that author, and as that genus contains the great majority of Mayflies found, not only in Tasmania, but also throughout Australia, it will readily be agreed that the first step in our study should be a thorough examination of this species and its life-history. This is the purpose of the present paper.

The Genotype of the Genus Atalophlebia

(*Atalophlebia australis*, Walker).

The genus *Atalophlebia* was proposed by Eaton in 1881, the genotype being designated as *Ephemera australis* (Walker), from Tasmania. In this genus Eaton (1884) included a number of species from Ceylon, Australia, New Zealand, Japan, South Africa, and South America. Most of these had been previously placed by him (1881) in the genus *Leptophlebia*, Wwd., Series 1.

Walker's original description (1853) devotes only a few lines each to the male imago and the subimago, the latter being queried as possibly not belonging to the same species. His descriptions deal only with colour and measurements, and hence it is not possible to determine the species with

certainty from his descriptions, but only from an examination of the actual type series. There are, however, two outstanding colour-characters in the description, viz., that the abdomen of the male imago is red (an unusual character for this genus), and that the forewings of the subimago have the black veins clouded with brown, and show "two broad, irregular, interrupted and very oblique bands." Eaton, when re-examining the type-series, made it clear that Walker intended by these latter remarks to indicate a clear space as distinct from the general shaded condition of the wing, and he describes this space as "a lambda-shaped space free of cross-veinlets and colouring, the long stroke of the latter being represented by a narrow clearing describing a gentle curve from the apex to the anal angle of the wing, and the short stroke by another narrow clearing running out from the midst of the wing-roots to the former." He adds that in some specimens the long and short strokes of the letter are separated by a little colouring.

During a recent visit to Tasmania I set myself the task of trying to solve, in my spare time, the problem of what this species really was. Arguing that Dr. Hooker probably collected either near Launceston, or near Hobart, or on one of the rivers crossed by the road connecting the two cities, I tried first the South Esk and Macquarie Rivers. I learnt from my friend Mr. Eric Hudson, of Launceston, a keen angler, that there was a rise of large Mayfly on the Macquarie River known as the "red spinner." This species was most abundant in November and December, and my visit was in February. However, at out first visit to the river, in spite of inclement weather, we succeeded in securing two female imagos and a subimago of a species which agreed closely with the descriptions given by Walker and Eaton. Later still, the same species was found commonly on Lake Leake. The nymphs were found abundantly under stones and rocks near the edge of the lake. Subimagos were reared from nymphs and imagos from subimagos, so that the specific identity of all the stages has been assured.

The next step was to gather information about the original type series, and also to have the new specimens compared with that series. I therefore wrote to Mr. D. C. Kimmins, of the British Museum, and sent him examples of the male imago in spirit. In his reply Mr. Kimmins states:

> "Neither Walker nor Eaton actually fixed the type of the species. I am able, however, to recognise the imaginal example from which Eaton made his

> figures for his 1871 paper, and, as far as I can tell, the other three imagines belong to the same species. . . . . None of Walker's imagines have more than two tail-filaments, but Eaton quotes two measurements, so there were probably three."

Mr. Kimmins very kindly sent drawings of the hindwing and of a KOH preparation of the male genitalia, prepared from one of the examples of the type series of imagos. From these, I am able to state with certainty that the species taken on the Macquarie River and on Lake Leake, and known to anglers as the "red spinner," is the true *Atalophlebia australis* (Walker). It now remains to redefine the genus in the light of modern knowledge, to indicate the characters in which it differs from related genera, and to describe and figure the various stages of the type species. I suggest that Tasmanian anglers should adopt the name "Large Red Spinner" for the imago (both sexes), and the very distinctive name "Lambda Dun" for the subimago (both sexes).

Family LEPTOPHLEBIIDÆ.

Genus *Atalophlebia* Eaton, 1881.

Imago.—Forewing well supplied with cross-veins, including a complete, or nearly complete, set in the costal space. Along distal margin of wing there are no isolated veinlets, but each longitudinal vein ends either simply or with a short, curved posterior branch. CuP always strongly and more or less sigmoidally curved. *Hindwing* with the costal margin strongly arched before half-way, but never angulated, then bending down so as either to approach very close to Sc for some distance, or even to fuse with it. Sc also arched, but not so strongly. R_1 straight. *Legs:* In the elongated forelegs of the male, tibia and tarsus are each about half as long again as femur; first segment of tarsus very short and closely attached to end of tibia, the other tarsal segments long and slender, 2 and 3 both longer than 4, 5 shortest. Middle and hind tarsi in male and all tarsi in female shorter than tibia, and appearing only four-segmented owing to fusion of first segment with tibia; comparative lengths of segments variable for different species. Tarsal claws alike, or nearly alike, narrow, hooked at tip, and carrying a transparent flange. *Genitalia of male:* Limbs of the forceps three-segmented, the basal segment very long, the other two very short. Penis variable, more or less

deeply bilobed. *Caudal filaments* variable, some species having three, some two, and some being variable (including the genotype); cerci always very long, especially in the males.

Subimago.—Differs from imago chiefly in its opaque wings and shorter caudal filaments, of which there are usually three, rarely only two. In most species the subimaginal stage lasts for a considerable time, from one to nearly three days, but in some cases less.

Nymph.—Of the crawling type, found clinging to submerged rocks, stones, or logs; more or less flattened, capable of running quickly. *Head* fairly large, with eyes placed laterally, antennæ longer than width of head. *Labrum* more or less excavated in middle of free border. *Mandibles* with outer margins strongly curved, with two well-developed incisors; prostheca present. *Hypopharynx* lobed, paragnaths strongly curved and spreading. *Maxillæ* with three-segmented palp and apically truncate inner lobe. *Labium* with three-segmented palps, broad paraglossæ and much smaller and narrower glossæ. *Legs* strong and stout, the femora rather broad, flattened, the tibia and tarsus slenderer, also flattened; *tarsal claws* denticulate. *Gills* seven pairs, on abdominal segments 1-7; each gill double, of very variable form. *Caudal filaments* three, the cerci long and stout, the appendix dorsalis usually well developed, but some times much weaker than the cerci.

Genotype.—*Atalophlebia australis* (Walker), from Tasmania. The curious form of the arched costa of the hindwing serves to distinguish this genus from all the others given by Eaton (1884). In the absence of any detailed knowledge of the genotype of *Atalophlebia*, it was, perhaps, unwise for later authors to have attempted the subdivision of this genus. Barnard (1932) separated off the South African species as a new genus, *Aprionyx*, on the character of the nymph possessing smooth tarsal claws. He did not know what the tarsal claws of the nymph of the genotype of *Atalophlebia* were like, since that nymph was then unknown. However, he argued that the Australian species were most likely to be similar to the New Zealand ones, which were known to have nymphs with denticulate tarsal claws!

Now that the nymph is discovered, it turns out that Barnard's surmise is correct. In most other respects, *Aprionyx* is very closely related to *Atalophlebia*. In imaginal characters, the only important difference that I can indicate is in the form of the penis, which is not bilobed as in *Atalo-*

phlebia, but either simple or, at most, notched at the tip. *Aprionyx* agrees with *Atalophlebia* in such important characters as the general venational scheme, including the shape of the arched costa in hindwing, in the form of the tarsal claws and genital forceps; also, amongst nymphal characters, in the general form of the antennæ and mouth-parts, notably in the broad truncated end of the inner lobe of the maxilla and the short distal segment of the palp, in the general form of the mandibles, hypopharynx and labium, though the latter has a much shorter distal segment on the palp in *Aprionyx*. The general form of the nymphs is much the same. If *Aprionyx* is to be accepted as a valid genus, it must be recognised that it is nevertheless extremely closely related to *Atalophlebia*.

Of the Chilean genus *Atalonella*, N. and M. (1924), I am unable to speak with certainty; but it appears to be distinguished from *Atalophlebia* by very slender characters. I do not regard the oblique pterostigmatic veinlets as a good generic character, since both oblique and nearly transverse types are found within the Australian species of *Atalophlebia*. *Atalonella* resembles *Atalophlebia* in the form of the penis, in having the tarsal claws of the nymph denticulate, and in other important characters. The chief distinguishing characters are to be found in the costal series of cross-veins being incomplete basally and in the different form of the hindwings.

What is really needed is a comprehensive monograph of all the forms originally included in the genus *Atalophlebia* (Eaton), with special attention to the differences exhibited by adults and nymphs in the different zoogeographical regions represented. The present paper is intended not only to clear up the situation as regards the genotype, but also to assist in laying the foundations for such a study, including a study of the abundant Australian and Tasmanian fauna.

Atalophlebia australis (Walker).

(Plate I., Figs. A and B; Plate II., Figs. 1-20.)

♂ *Imago* (Plate I., Fig. A).—*Total length* of body (dried), 8 to 11 mm.; *abdomen*, 5 to 7 mm. *Forewing*, 9·5 to 12 mm.

Head.—General colour black, with a touch of reddish-brown on the occiput; *antennæ* very short, dark brownish; *compound eyes*, with the large inner division brownish-grey, the smaller outer division grey; *ocelli* greyish-white; parts around the mouth reddish-brown.

Thorax.—Shining black above, with two small, reddish-brown spots near posterior angle of mesonotum. Sides mottled in black and reddish-brown, with two very irregular patches of whitish, one close to the base of each wing, the white in each case more or less surrounding a dark brownish patch extending obliquely away from the wing-base. *Legs:* Forelegs (Fig. 4) 7-9 mm. long, blackish, tinged with brown at base of femora and on tarsi; tibia about equal to tarsus in length, and each of these half as long again as femur; comparative lengths of tarsal segments, in descending order, 2, 3, 4, 5, 1; middle and hind legs (Fig. 5) about 5 mm. long, reddish-brown; comparative lengths of the four visible segments (omitting 1), in descending order, 5, 2, 4, 3. *Tarsal claws* (Fig. 6) rather long, slender, similar, terminally hooked, and each carrying ventrally a transparent flange extending apically as far as base of hook, where it is strongly angulated.

Wings.—Forewing (Fig. 1) subtriangular, with tornus at about two-sevenths of wing-length. Costa nearly straight from brace to pterostigma, carrying a complete series of costal veinlets, 7 to 10 in number up to the bulla; pterostigma beginning not far distant from bulla, and carrying a large number of oblique veinlets, some simple, some distally forked, and a few connected by cross-struts. General colour of all veins reddish-brown, a part of C, R_1, and MA somewhat darker than the rest. Wing-membrane mostly hyaline, but base of wing up to brace suffused with yellowish-brown, and the costal and subcostal spaces appearing throughout also more or less suffused with pale reddish-brown owing to suffusion of the cross-veins in these areas; this suffusion is most marked in the pterostigma and on the whole of the cross-veins of the subcostal space; in particular, there is a dark suffused patch around the cross-vein below the bulla, and a much larger suffused patch for two cellules below the beginning of the pterostigma. The cross-venation is sparse between the branches of Rs, except distally, and also basally between the branches of MA, MP, and CuA. *Hindwing* (Figs. 2, 3) 2 to 3 mm. long, the costal margin strongly curved to about half-way, where it bends downwards so as almost to meet Sc, and then runs very close above it, finally meeting it at about four-fifths of the wing-length. Most of the broad portion of the costal space is devoid of cross-veins, but there are two or three present just as it begins to narrow, and usually several more in the extremely narrow part. In some of the specimens, particularly those of smaller

size, the costa meets Sc more quickly, at about two-thirds of the wing-length, and thus the narrowed portion of the costal space is much shortened (Fig. 3). Sc is evenly arched upwards from base to where it approximates to costa; thence onward it is nearly straight. R_1 is usually straight, forming, as Eaton put it, " the chord of the arc " above it. A complete series of cross-veins exists between Sc and R_1, but the individual cross-veins are variable in position in different specimens. Rs is secondarily attached to MA, with or without a free piece of the original stem remaining basally; it carries a single triad. MA is either simple or with only a single terminal posterior branchlet. MP has a well-developed triad arising before half-way and usually a short terminal branchlet on MP_1. Both CuA and CuP are fairly straight veins with well-developed terminal branchlets. 1A is a simple, curved vein. The wing is very broad in the middle, about two-thirds as wide as long, but distinctly narrow basally, the posterior margin from base to end of 1A being almost straight.

Abdomen.—Seg. 1 short, broad, blackish, closely attached to thorax; 2 short; from 3 to 7 the segments become progressively longer and somewhat narrower; 8 as long as 7, broadening slightly distally; 9 two-thirds as long as 8, slightly angulated or spined postero-laterally; 10 considerably shorter and a little narrower than 9. Segs. 2-10 generally deep reddish in colour, 2-3 slightly tinged with reddish-black above and on sides, 4-8 on sides only, 9-10 slightly darkened; some indication generally of a paler transverse band along posterior margin of 2-7, and in some specimens also of a paler mid-longitudinal line. *Genitalia* as in Figs. 7-8, the forceps-basis rather short and broad, slightly notched in middle of posterior border; forceps three-segmented, the first segment fairly broad basally, very long, the distal half of the inner margin somewhat narrowed or excavate; second and third segments very short, subequal in length, suboval in shape, the two taken together only about one-sixth the length of the basal segment. Penis broad at base, tapering distally by its sigmoidally curved sides to two diverging apical lobes separated by a deep subtriangular cleft; each apical lode bears ventrally a curious structure which appears to be a sac or pocket of delicate chitin, the two pockets being just in contact on the middle line. Viewed in profile (Fig. 8) the penis is nearly straight, a little inclined upwards distally and narrowed for its distal third; the pockets can be clearly seen just projecting ventrally. In some specimens

ATALOPHLEBIA AUSTRALIS. (Walk.)

Imago and Subimago—Enlarged.

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the median cleft does not reach as far as the pockets, in others it appears to pass well down below them. *Cerci* stout, 17-25 mm. long, blackish with reddish-brown tips; *appendix dorsalis* extremely variable, being entirely absent in some specimens, short and slender in others (from one-third to one-half as long as cerci), and, in others again, almost as long, though not as stout as the cerci; colour blackish.

♀ *Imago.*—Differs from the male in being of somewhat stouter build and often of darker colouration; the reddish-brown shading along the costal margin of forewing is more pronounced. Forelegs shorter than in male, 5 to 6·5 mm., tarsus with only four distinct segments, 1 being fused with tibia; comparative lengths of segments, in descending order, 5, 2, 3, 4; colour blackish. *Subgenital plate* entire; *subanal plate* deeply, almost semi-circularly, excised (Fig. 9). *Cerci* generally somewhat shorter than in male, 15 to 20 mm. long; *appendix dorsalis* equally as variable as in male.

Subimago (both sexes) (Plate I., Fig. B).—General appearance when freshly emerged, black, with the pattern of the folded wings blackish and very prominent. In the dried specimen, the body-colouring becomes black tinged with greyish, and the shaded areas of the wings dark fuscous, with a slight indication of brown along the costa. The general pattern of the forewings is brought about by the irregular placing of the cross-veins and their being more or less shaded with blackish. This pattern may best be described as a general rather mottled dark ground colour, with a hyaline space in the form of a Greek letter *lambda* or an inverted uncial Y. The long stroke of the *lambda* begins at the apex, and runs with a gentle curve concave to the outer margin, so as to end at a point a little beyond the tornus; the short stroke runs from the wing-base between MP and CuA, and usually, but not always, fails to meet the long stroke at about its lower third owing to the presence of two clouded cross-veins, one between MP_1 and MP_2, the other between MP_2 and CuA. The heaviest shading occurs along the margins of the lambda-mark, along the whole of the costa except near its middle, over the whole of the pterostigma and also below its middle portion. In the hindwing, all the cross-veins and terminal branchlets are heavily shaded. *Legs* blackish, with a touch of brown on femora. *Caudal filaments* much shorter and more weakly developed than in imago, greyish-brown.

Nymph (Figs. 10-20).—*Total length* (excluding tail-filaments), 9 to 11·5 mm. *Cerci*, 10 to 14 mm.; *appendix dorsalis* generally slightly shorter.

General form subcylindrical, broadest across mesothorax. the thorax and abdomen convex above, flattened beneath. General colour a rich brown. *Head* about as long as wide, broadest across the eyes, which are black and situated postero-laterally; in front of the eyes runs a pale transverse line indicating the suture between epicranium and frons; ocelli blackish, the two lateral ones set just behind the suture, in line with the anterior angle of the eyes; the median one well forward. Antennæ about half as long again as the head, very slender, pale semi-transparent brownish-yellow, set wide apart and just forward of the median ocellus. Clypeus and labrum much narrower than frons, the outer contour of the head laterally being completed by the broadly rounded outlines of the mandibles.

Mouth-parts.—Labrum (Fig. 13) about twice as wide as long, its lateral borders well rounded, with short hairs, middle portion of anterior border hollowed out, the sides of the hollow weakly crenulate; surface generally hairy, there being two sets of short, dense hairs arranged transversely, one on either side of the middle line, and two slightly curved rows of closely set sockets carrying longitudinally directed hairs, one row curving around the median incision of the free border, and a shorter row further basad, crossing the two sets of transverse hairs. *Mandibles* (Fig. 14) strong and stout, with very curved outer margins; incisors large and separate, each subdivided apically into two or more separate teeth; prostheca inserted close to inner incisor and consisting of a slender process, shorter than the incisor, smooth in the right mandible and apically crenulate in the left, together with a brush of hairs about twice as long (Fig. 15); molar areas with a grid formed of about a dozen transverse ridges or laminæ, each fringed with minute, delicate hairs closely set; in the right mandible, the molar area ends in a very acute process, the two mandibles working together very asymmetrically. *Hypopharynx* (Fig. 16) very complex, consisting of a divided median lobe fairly strongly chitinised around the edges, and two slenderer, pointed processes of very thin, transparent chitin, longer than the median lobes: *paragnaths* large, transverse, strongly curved backwards, the anterior border with a complete fringe of hairs. *Maxillæ* (Fig. 17) with three-segmented palp, the basal segment subcylindrical, smooth, the middle segment narrowed basally, longer than the basal segment, and carrying a series of stiff setæ on the inner surface and scattered soft hair along the outer margin, the distal segment very

short, about half as long as the middle segment, and with plentiful soft hairs on its outer margin to tip; inner lobe broad and truncate, with a dense brush of curved hairs along the whole of its outer margin. *Labium* (Fig. 18) with three-segmented palp, the basal segment transverse, broad, the middle segment narrowed basally, not so wide, about as long as the basal one; the distal segment cornute, with short, stiff setæ along inner margin and a row of about six longer ones placed longitudinally on outer surface; glossæ small, close together, standing out almost at right-angles to the rest, and resembling the soles of a pair of feet standing together; in Fig. 18 they are shown as pressed down on a slide with cover-slip; paraglossæ large and broad, the outer margins strongly curved and very hairy, the inner margins forming almost a right angle with them, straight and almost touching the glossæ; distal half of surface very hairy.

Thorax strongly built, convex but not humped. *Prothorax* well developed, about as wide as head, less than half as long as wide, the anterior margin concave, the posterior straight, the lateral margins produced into a narrow, curved, transparent flange; colour dark-brown, with a pale mid-longitudinal line. *Pterothorax* (combined meso and meta-thorax) generally dark-brown, slightly mottled with paler patches, and having a pair of rather indistinct dark blotches near antero-lateral angles; the pale mid-longitudinal line of the pronotum is continued very faintly backwards for some distance on the mesonotum; wing-sheaths broad, reaching to end of third abdominal segment, dark brownish. *Legs* (Fig. 11) subequal, the middle pair slightly shorter than the other two, the fore pair with the femora slightly broader and tibiæ slightly longer than the others; femora broad, flattened, armed with numerous short, stiff setæ; tibiæ narrow, cylindrical, somewhat flattened, a little longer than femora in forelegs, a little shorter in the other two pairs, inner margin armed with fine hairs and setæ; tarsi about half as long as tibiæ, flattened cylindrical, slightly narrower, inner margin armed with short setæ; *tarsal claw* (Fig. 19) well developed, about half as long as tarsus, strongly hooked at apex, and carrying a series of fine denticles along its inner margin. Colour medium brown, banded with darker brown, as follows:— Femora with three bands, an indistinct one near base, and two fairly well defined bands, one across middle and one near apex; tibia with a rather narrow basal band and a

broader band covering about the first two-thirds of the distal half; tarsus with a broad band covering a little more than the basal half.

Abdomen convex above, flattened beneath, tapering gradually from base to apex; the segments lengthening from 1 to 8, but 8 only slightly longer than 7; 9 markedly shorter than 8 and slightly narrower; 10 much shorter and narrower than 9. Segment 1 has no lateral flange, and its postero-lateral angles are almost right-angles; segments 2 to 9 carry lateral flanges produced postero-laterally into sharp, backwardly directed spines; the spines of segment 2 are the smallest, those of succeeding segments becoming larger up to segments 7 and 8, that of segment 9 smaller again; segment 10 has the postero-lateral angles slightly prominent, rounded. Colour of abdomen dark-brown, with a pale, whitish, subtriangular spot covering the middle of each suture from 1-2 to 8-9; a pair of small, oval, pale-brown spots placed antero-laterally on segments 2-9, the dark-brown surrounding them running out on to the flange beyond them; less distinct but larger pale areas are indicated postero-laterally but closer together, but these are only at all well indicated on segments 4 to 9; segment 10 darkest at sides and posteriorly. On the flanges of segments 2 to 7 there is an oblique blackish patch near the insertion of each gill; tips of all lateral spines slightly darkened. *Gills* (Fig. 20) seven pairs, each gill consisting of a pair of lamellæ prolonged into three slender, pointed, digitate processes; the outer and upper lamella is somewhat narrower than the inner and lower, and has a stout tracheal trunk which gives off short weak branches basally followed by strong branches into each of the three digitate processes; the inner and lower lamella is broadened on one side, and the three tracheæ running into the processes arise separately from near the base of the lamella. In the natural position, the upper lamella partly conceals the lower; in Fig. 20 they have been separated to show their full outlines. The largest gills are on segments 2 to 5, those of segments 1 and 6 are smaller, about equal; those of segment 7 the smallest and shortest of all.

Types.—In reply to a letter inquiring about the type series in the British Museum, Mr. D. E. Kimmins has very kindly supplied the following information:—"As the type of the species has not been fixed, I would suggest that you designate the imago figured by Eaton as the type (it is the most complete)." This course would seem to be a wise one,

and I therefore adopt it here, designating the specimen indicated by Mr. Kimmins as the *holotype* male imago of the species. The remaining male imagos thus become paratypes. A female imago from my own collection is designated as the allotype.

The problem of the subimago described by Walker is not so easy, since it will be remembered that he attached a query to the word in his description, thereby indicating his doubt as to whether it really belonged to this species. It appears, therefore, wiser to make quite certain by designating a good specimen of the subimago from my own collection as type subimago, and a specimen of the nymph, also from my own collection, as type nymph. In order that these may all be readily accessible to students, they are being presented to the British Museum Collection.

Localities.—Macquarie River and Lake Leake, Tasmania (February, 1933). The specimens taken on the Macquarie River are generally somewhat smaller than those from the lake, where the conditions are exceptionally favourable for the nymphs.

Habits.—The nymphs are found under logs, rocks, or stones submerged in the water, either along the edge of the river or close to the shore of the lake. It evidently feeds on humus and decayed vegetable matter. On opening the mouth of a captured nymph, it will be found to be full of minute particles of vegetable material brushed off and collected by the action of the mandibles and maxillæ. The nymph is a sluggish creature, but can run fairly quickly when attempting to escape.

The few subimagos captured were all taken on cold, windy days, either clinging to reed-stems near the margin of the river, or resting on the ground some way back from the lake, during a strong gale. The lambda-pattern of the wings is very conspicuous in the resting position, and makes this subimago comparatively easy to recognise, though those of certain other as yet undescribed Tasmanian species approach it fairly closely.

The imagos were taken, in the case of the Macquarie River specimens, either drowned and floating on the water, or by rearing from subimagos. At Lake Leake, in spite of the high wind, they were caught flying strongly against the wind, along the shore of the lake. Every time the wind

abated slightly, the Mayflies would be on the wing at once, buffeted about as they were, until compelled again to take shelter by resting on the ground, or on rocks or the trunks of near-by trees.

Value as Trout-Food.

Mr. E. Hudson informs me that there is a big rise of this Mayfly on the Macquarie River in November and December, and that the trout feed on it readily. Observations are required concerning the method of disclosure of the subimago from the nymphal skin; especially whether any considerable number of nymphs emerge quite close to the banks, or whether most of them rise well out into the stream, so that the floating subimago or "lambda dun" becomes an attractive bait for the rising trout while it is drifting towards the shore. Further observations should also be made to determine the dates of the first and last appearances of this Mayfly during the season. It is known already that it lasts from November to the end of February, and it evidently constitutes one of the most important articles of food for trout in the Macquarie River.

As regards Lake Leake, I was not able to go out on the lake and dredge the bottom for nymphs, nor did I see any rise of the Mayfly during the hour or so that I was there. All the nymphs that I found were clustered on the undersides of submerged stones, rocks, and logs along the edges of the lake; in these places they were very abundant, twelve full-grown nymphs being taken from beneath one small submerged stone. The value of the species to anglers on the lake depends largely on how frequently the nymphs rise to the surface well out from the shore, so that the "lambda duns" have to drift on the surface of the lake before reaching shelter, and also on whether or not the imagos or "large red spinners" do normally, in bright sunny weather, fly over the lake in such a way as to attract the trout to rise at them.

It would manifestly be unwise to disturb the balance of nature on Lake Leake by the introduction of other species of Mayflies until such time as the above observations have been carefully made. Further, a complete survey of the Mayfly fauna of the lake is required, including the life-histories and distribution throughout Tasmania of the species found there. When that has been done, the value of such an experiment as the introduction of the nymphs of

the "Penstock Brown" or other species of Mayfly can be scientifically calculated, and it may well be that such introductions may then be shown to be desirable for the improvement of the trout-fishing.

In the meanwhile, I think that the supply of this Mayfly in the Macquarie River could be augmented, or at any rate prevented from dropping, by a judicious use of more or less decayed timber, such as rotten logs. When old willows or gum-trees are cleared away near the river, they might be cut into convenient lengths, and placed in various parts of the river in such a way that they are not likely to become snags for the anglers. The Mayfly nymphs will find their way to these logs in large numbers, and, hiding in their cracks and crannies, proceed to obtain a rich living from the vegetable material which collects on them and from the products of their decay. In Lake Leake there would appear to be already a plentiful supply of decaying wood, since part of the area submerged to form this lake was originally forest. This is probably one of the chief reasons for the abundance and large size of *Atalophlebia australis* on this artificial sheet of water.

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Legends of Figures, Plate II.

Figs. 1-9. *Atalophlebia australis* (Walk.). Imago, parts.

Fig. 1. Forewing, with New Notation of Venation. A_1, A_2, A_3, the three convex anal veins. IA the interpolated concave anal vein; CuA, anterior cubitus, convex; CuP, posterior cubitus, concave; MA, anterior median, convex; MA_1 MA_2 its branches; IMA, interpolated concave sector of triad; MP, posterior median, concave; MP_1, MP_2 its branches; IMP, interpolated convex sector of triad; *pt* pterostigma; R_1, radius; Rs, radial sector; R_2 to R_{4-5} its branches; IR_2, IR_{3a}, IR_{3b}, interpolated convex sectors of triads; Sc, subcosta (x 10).

Fig. 2. Hindwing of same specimen as Fig. 1, enlarged twice as much (x 20). Lettering as in Fig. 1.

Fig. 3. Hindwing of holotype male, from drawing sent by Mr. D. C. Kimmins.

Fig. 4. Tarsus of foreleg of male (x 20), with portion of tibia.

Fig. 5. Tarsus of hindleg of male (x 20), with portion of tibia.

Fig. 6. Tarsal claws from hindleg of male (x 100).

Fig. 7. Genitalia of male, dorsal view after removal of tenth tergite and appendages (x 50). *gp* lateral gonapophysis or forceps-basis; *pe* penis; *st* gonostyle.

Fig. 8. The same, viewed laterally. Lettering as in Fig. 7.

Fig. 9. Subanal plate of female imago (x 40).

Figs. 10-12. *Atalophlebia australis* (Walk.). Nymph and parts.

Fig. 10. Nymph (x 10). Colour-pattern omitted except on abdominal segments 5–8; gills only represented on left side, so as to show shape of abdominal segments on right; caudal filaments cut short.

Fig. 11. Middle leg (x 32).

Fig. 12. Basal segments of cercus (x 100).

Figs. 13-20. *Atalophlebia australis* (Walk.). Parts of nymph.

Fig. 13. Labrum (x 50).

Fig. 14. Mandibles, dorsal view (x 50).

Fig. 15. Prostheca of left mandible (x 100).

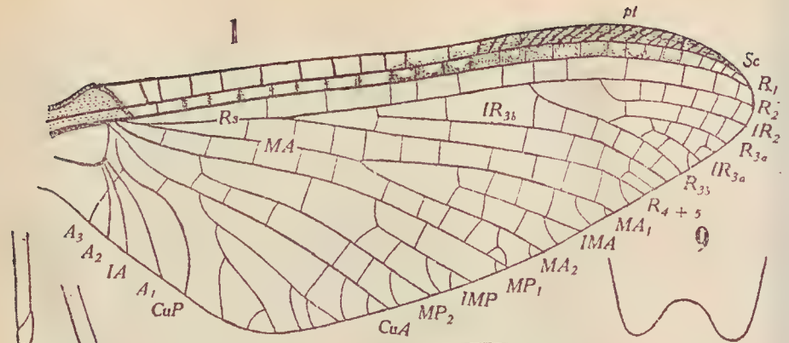
Fig. 16. Hypopharynx and paragnaths (x 50).

Fig. 17. Maxilla (x 50).

Fig. 18. Labium (x 50.)

Fig. 19. Tarsal claw (x 100).

Fig. 20. Pair of gills from second segment of abdomen, with the two lamellæ well separated to show their complete forms; the outer and upper lamina above the inner and lower lamina below (x 30).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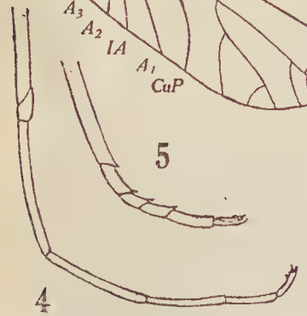
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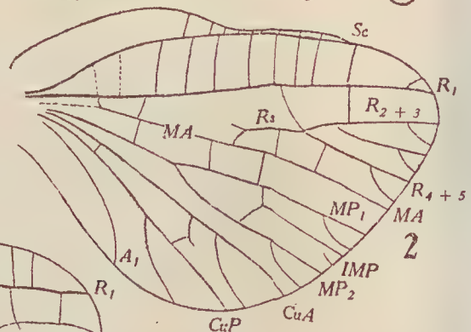
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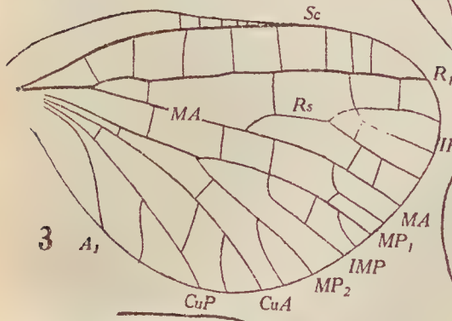
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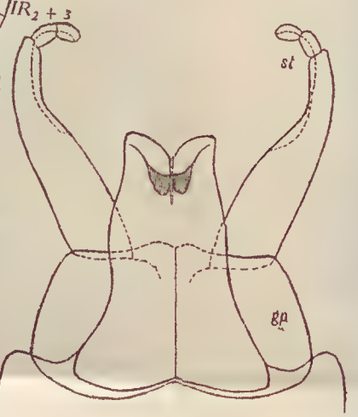
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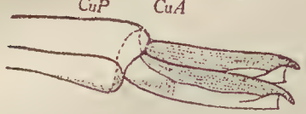
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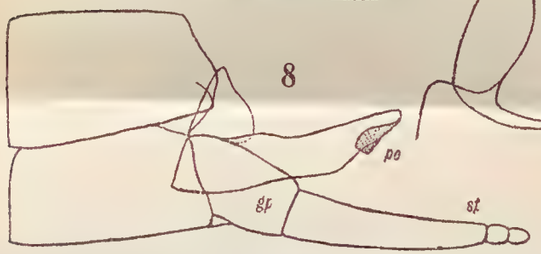
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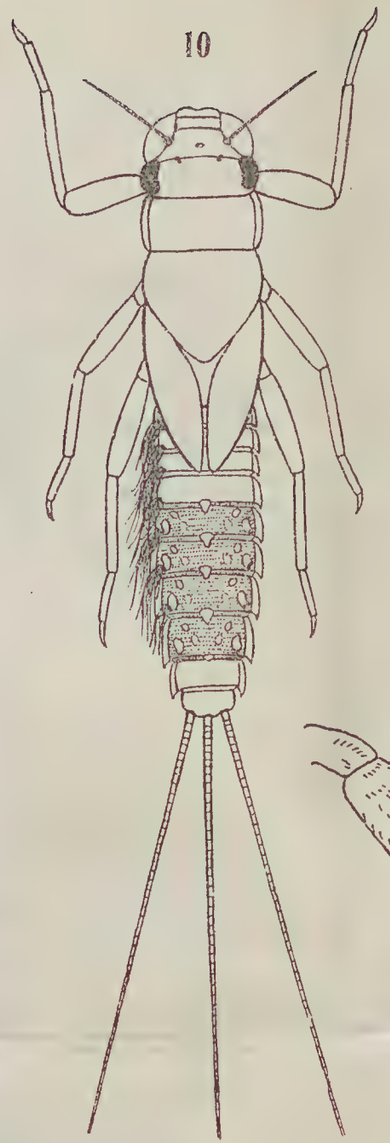
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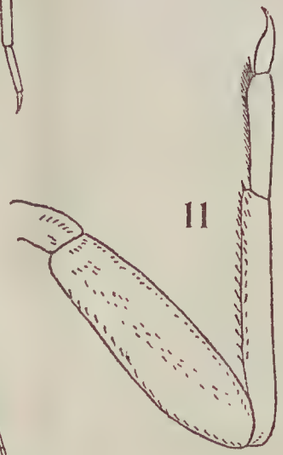
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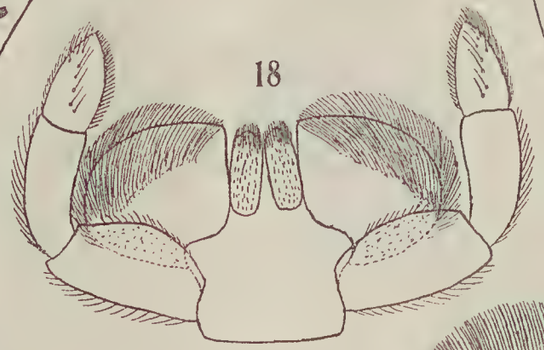
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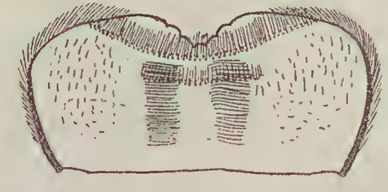
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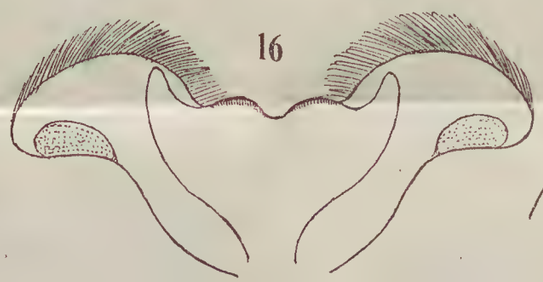
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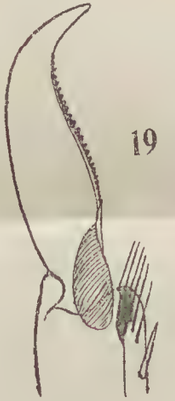
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NOTES ON A FOSSIL PINE FROM THE PERMO-CARBONIFEROUS STRATA *(DADOXYLON PENMANI*, SP. NOV.).

By

H. H. Scott,

Curator, Queen Victoria Museum and Art Gallery, Launceston.

(Read 24th July, 1933.)

General Notes.

The fossil came from the air-shaft of the Aberfoyle Mine, and its age was determined by the Government Geologist (Mr. P. B. Nye) as being Permo-Carboniferous. This field note is of some importance, since of recent years the old genus *Dadoxylon* has been revived to meet the case of all such Australian Palæozoic specimens as are duly segregated from the more ancient type of *Cordaites*. In the same connection the genus *Araucarioxylon* is now restricted to Mesozoic pines, of more or less Araucarian habit. Such being the case, our fossil must therefore be either a true survival of the Devonian *Cordaites*, or else the more recently evolved *Dadoxylon*.

In his "Prodromus of the Palæontology of Victoria" Sir Frederick McCoy says that *Cordaites australis* has no medullary rays, but retains the older structure of scalariform ducts. As the present specimen *has medullary rays*—although, curiously enough, quite absent from many chipped specimens of the wood—and *no ladder ducts*, it seems correct to classify it as a *Dadoxylon*. In the item of a species, I have called it "*Penmani*," after Mr. C. J. Penman, who secured the fossil for us.

Appended is a detailed account of the microscopical structure of the three faces of the wood.

Transverse.

It is impossible, with the imperfect state of preservation, to obtain a series of zonal growths, but from microscopical specimens the following can be determined:—

The tracheids are thick-walled, and both quadrangular and circular (or an approach to it); the wood has been

badly compressed during preservation, so much so that the autumnal wood zone has been driven out of alignment. No evidence of any value can be collected from this aspect of the wood respecting the medullary rays *in the majority of instances;* indeed, it was at first regarded as useless to expect any; but a fortunate scrap came to light in which the structure was good enough to determine the following facts:—

The rays may be very narrow, and apparently only a single tier wide, or two or three tiers in structure, the wider ones showing most commonly in the autumnal wood; possibly distortion may here accentuate appearances to some extent.

Some, beyond all doubt, grow wider in the autumnal zone, and can be traced throughout their course.

Radial.

As might be expected from the transverse structure of the wood, the radial aspect depicts an even grain, and by measurement it was found that an average tracheid was 1-500th of an inch wide, as against the 1-438th of an inch for *Araucaria cunninghami,* while *Agathis* was slightly coarser. Fractured specimens showed that quite a number of pieces could be found without any medullary rays at all, and in making a duplicate study set much waste was involved. When found, however, the rays were noted as being in bundles of 1, 2, 5, 6, 8, 9, 10, 12, 15, 22, and all very strongly built. In the fossil state, the rays, as they cross the tracheids, communicate by a single perforation that occupies the whole of the crossing space, and may have done so in life, although a network of small apertures might have so commingled. Against the latter idea, however, must be set the fact that all the tracheid-bordered pits are perfectly preserved, and many modern pines still adopt the single aperture plan. The ray pits in *Araucaria cunninghami* are quite often *bordered* pits, even when the tracheids on either side of the ray band are devoid of pits. These in tangential section give very clear proof of their structure! As I cannot, in the fossil, trace multiple pits, nor evidence of there being bordered pits in the rays, I shall record the ray pits as being the full size of the ray-tracheid crossings.

The bordered pits in the tracheids are in double rows, and run throughout their length without any special crowding at the ends. Now and again an end may develop three rows of pits, with very slight dilation, but without the oval termination seen in Araucarian pines. On the whole, the tracheid ends meet and blend with very little upward or downward displacement, and some junction by direct harmonia. Where the ray bands are widely separated the wood roughly suggests the Araucarian habit, but where the bands are numerous it recalls *Agathis*.

Tangential.

No tracheid-bordered pits have been detected in this aspect of the wood, and the medullary ray evidence is not as satisfactory as that obtained from the fortunate fracture in transverse section. The ray elements in single tiers have been detected, but where two or more tiers existed the evidence is obscure, even under the best microscopy, since all the elements seem compressed into a single mass.

As far as is known to me no pine of this age has been listed for Tasmania under the generic name of *Dadoxylon*, although our coal measures frequently yield leaf impressions of *Nœggerathiopsis*, which Newell Arber regards as being the foliage of these conifers (" The Glossopteris Flora," page 191), rather than that of *Cycas*, as suggested by Fiestmantel.

Taxonomic.

Genus — *Dadoxylon*. Species — *penmani*. (Sp. nov. — Extinct.)

From the Tasmanian Permo-Carboniferous, and the oldest plant-yielding horizon as yet explored.

Three cotypes in Queen Victoria Museum, Launceston.

ADDENDUM.

The microscopy has been done with the stereoscopical binocular and the best lenses, fitted with Lieberkuhns, up to powers as high as the $\frac{1}{4}$ of an inch, the material being factured.

ON AN UNUSUAL FORM OF STONE FROM A TASMANIAN NATIVE CAMP.

By

H. Stuart-Dove.

Plate III.

(Read 25th September, 1933.)

Until seven or eight years ago there existed a very interesting native camp-site just to the west of Mersey Bluff, a diabase headland which projects into the sea about a mile from Devonport town. This site comprised: a chipping-mound, where the implements where shaped from pebbles of various composition collected on the beach; a feeding-ground between the mound and a belt of sand which shut off the camp from the sea-winds; and a fresh-water lagoon on the other or land side of the camp, which lagoon was in former days overhung by tall swamp tea-tree. Thus the natives had everything at hand to make life pleasant—warm sand to bask in, fresh water to drink, plenty of shell-fish in the salt water and marsupials in the scrub, and an inexhaustible supply of large pebbles—chert, breccia, and quartzite—from which to fashion their hand-axes and scrapers. Before the site was destroyed by sand-carters, I collected there a number of neat little axes and knives, and a quantity of scrapers of various types; also a flat, circular pounding-stone, the top of which was protruding above the sand; when excavated, it proved to have in its centre some of the red ochreous material still adhering, which had been pounded by it, and used for decorative purposes by the men.

The most unusual find on this site was a stone of cylindro-conical type, which was lying on the surface; a number of these have been collected in the Darling Valley and other parts of New South Wales, and a correspondent in that State who has a large collection writes me that some have come to light in Africa and one in New Zealand. The specimen found at the Bluff camp appears to be the only one so far recorded from Tasmania, so that the distribution is strange and interesting.

[*H. Stuart-Dove Photo.*

Cylindro-conical Stone Found on Site of Old Native Camp at Mersey Bluff, N.W. Tas.

NATIONAL

According to the Ethnological Guide to the National Museum, Melbourne, the New South Wales specimens are composed of either slate or sandstone, and a feature peculiar to them is the saucer-shaped base. The Tasmanian specimen has not this hollowed base, but an attempt seems to have been made to produce it, as a chip has been taken out at one side of the base and a slight indentation made on the opposite side, as if with the intention of lifting out a large flake, but the material, an intensively hard breccia-quartzite, resisted the crude implements of our natives, and the flake was not removed.

These cylindro-conical stones were almost certainly put to some ceremonial use, but to what exact form of ceremony has not been determined. The Guide already quoted states that they have been variously designated as ceremonial stones of some nature, pounders, phallic symbols, or grave-markers. Both the correspondent in New South Wales and myself consider it highly probable that they were phallic emblems, which were employed, in some form or other, by so many primitive peoples.

The dimensions of the Mersey Bluff specimen are—

Length, 180 m.m. = 7"
Diameter at base, 71 m.m. (approximately).
Diameter at centre, 65 m.m. (approximately).
Diameter near the blunt top, 46 m.m. (approximately).
Weight, 3 lb. 9½ oz.

NOTES ON THE HABITS OF THE EXTINCT TASMANIAN RACE.

[No. 3.]

By

W. L. Crowther, D.S.O., V.D., M.B., B.S.

Plates IV.-V.

(Read 11th September, 1933.)

Introduction.

It is not proposed in this paper to attempt any detailed description of the method by which the Tasmanians disposed of their dead, but rather to give a brief account of the discovery of aboriginal remains at Sandford during April, 1927.

On the 12th of that month Mr. Alfred Morrisby showed me a cranium that he had found partially exposed in his orchard some days before. This orchard had been under cultivation for between 20 and 30 years, and had been ploughed six months previously.

It is possible that the cranium was turned up at that time, and the injuries it had sustained were inflicted by the ploughshare.

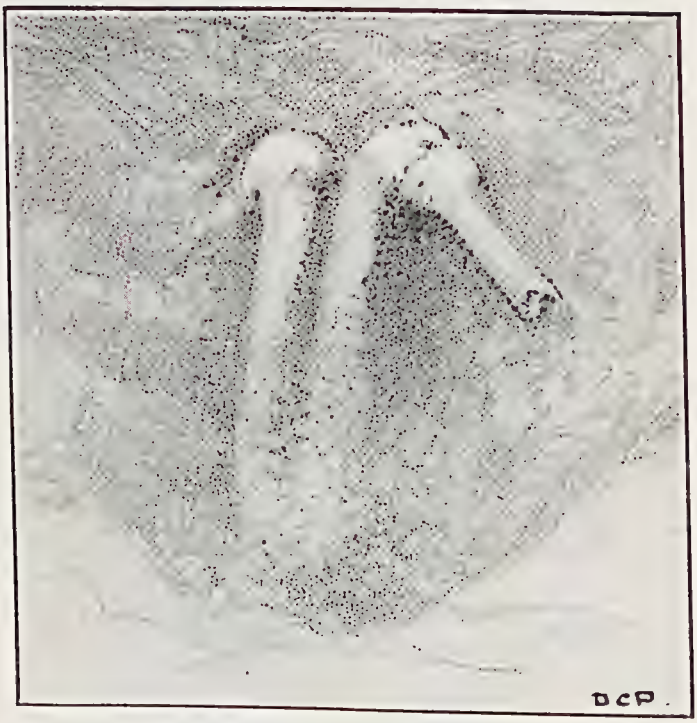
The presence near-by of a spring of fresh water and the abundant remains of oyster shells clearly pointed to the fact that it was on the site of an aboriginal camping-ground.

Four days later, in the company of Dr. Inglis Clark, a detailed examination of the locality of the find was made.

Description.

The cranium—No. 86, Tasman Series (Wunderly and Wood-Jones, 1933)—showed the characteristics of the Tasmanian type, and was that of a male of full adult age. The teeth were complete, except for the upper central incisors, which had dropped out.

When found it was on the left side, with portion of the left occipital area exposed.



Illustrating the Strongly Flexed Portion of the Bones of the Left Side.

NATIONAL MUSEUM

The right temporal area was very friable, and the zygoma, outer wall of the orbit, and a considerable area of the superior maxilla of the same side, wanting (as a result of weathering or trauma).

The cranium was heavy and sodden with moisture and the cerebral cavity filled with sand.

The slight depression from which the skull had been lifted some days previously showed small pieces of bone scattered over an area of about 2 square feet. Interest was at once aroused by the fact that they had been broken into pieces not longer than 3 to 4 inches in length and showed traces of exposure to fire. One fragment was from the right scapula, others of more dense structure were probably parts of the humerus, radius, and ulna of the same side.

It is difficult to account for the broken-down condition of these bones, except by deliberate repeated fractures following partial incineration—crushing or accidental trauma does not appear to have been the cause.

A few feet away from these fragments nodules and a flat piece of red ochre were found—brought almost certainly from considerable deposits of ochre in the face of a steep bank of the adjacent lagoon.

Having carefully looked over the surface, we commenced to dig with our hands and a small entrenching tool.

Two areas of sand, each of about one cubic foot, were found to be discoloured by carbon and ashes.

Extending the search 4 feet away more bones were recovered, proving to be parts of several vertebræ (cervical and thoracic), two clavicles, a mandible in two pieces (less the ramus of the left side), and small portions of ribs.

Under these fragments a more solid mass was to be felt, which, on careful removal of the sand, proved to be a most interesting grouping of bones.

There were—

(1) The proximal portion of the left humerus, with adjacent articular area of the scapula.
(2) The distal portion of the femur of the same side, with the patella attached.
(3) The proximal portion of the tibia.

Their relationship was as shown in Plate IV., and drawn from a very poor photograph taken at the time.

The bones of the leg were flexed at the knee to such an extent as to bring them into the closest contact. The body as a whole must have been placed in a position of marked flexion (Plate V.), as the head of the humerus was in intimate contact with the sharply flexed knee. To attain this result the knees must have been tucked up until almost under the chin, either before the onset of rigor mortis or after decomposition had set in.

Calder (1875) states that before incineration the Tasmanians were observed to tie the limbs in this way by thongs of rushes or grass.

The Position of the Body.

It was on its left side, the plane horizontal or with a slight inclination towards the vertical.

The level at which this group of bones was found was about 18 inches below the surface.

Detailed search, whilst revealing no trace of such bones as the lower thoracic or lumbar vertebræ, those of the pelvis, or below the middle of the tibia, showed a large area of sand, discoloured by fire, and containing ashes, indicating an attempt to dispose of the body by burning.

Through some want of fuel or shift of wind the incineration was incomplete, destroying only that part of the body below a line drawn obliquely across the upper thoracic vertebræ (see unshaded area in Plate V.).

This would leave undestroyed the bones already described, the ashes representing the remainder which had been incinerated.

Conclusion.

We know from several eyewitnesses of funeral ceremonies at Bruny Island and at Whybalena that the Tasmanians disposed of their dead by burning or by depositing the body in a position of strong flexion in a hollow tree.

In both these procedures it was customary to place the body in an upright position. In other instances (usually with children) the parents carried certain bones or wore them suspended around their necks.

The discovery at Sandford confirms the evidence as to the strongly flexed position of the body before incineration, and shows that in this instance the latter was lying on its left side, and not upright.

Supposed Position of Body. (Unshaded area shows complete incineration.)

As this is the first occasion since Peron (1809) upon which such human remains have been discovered, it seems only fitting that the details be placed in record.

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NOTES ON A MEMORIAL TO ALFRED BARRETT BIGGS, ASTRONOMER.

By

A. L. Meston, M.A.

(Read 25th September, 1933.)

The latitude of Launceston is officially given as 41° 26′ 1″ south and the longitude as 147° 7′ 49·5″ east, but there is at present not the slightest indication of the position from which those calculations were determined. It is proposed by the Northern Branch of the Royal Society to mark the position adequately and fittingly by the erection of a pillar suitably inscribed. The observations were made by the late Mr. Alfred Barrett Biggs, F.R.S., who for many years had an observatory in what was then called the Depot Grounds, but which to-day is termed Royal Park. Mr. Biggs was one of that noble band of amateur scientists to whom the world owes so much. He was born in London on the 10th of April, 1825, and was the eldest son of Mr. Abraham Biggs, builder and contractor. He arrived in Hobart Town with his parents in 1833. As a youth he joined the staff of the Commercial Bank of Tasmania at Hobart, but subsequently resigned in favour of teaching. He held good positions in the State Departments of Victoria and Tasmania for over 27 years. In 1880 he entered the Launceston Bank for Savings as accountant, a position which he filled with distinction until a few weeks before his death on the 19th of December, 1900.

Seismology and astronomy were the subjects that lay nearest to his heart. On a convenient site in Royal Park he set up a freestone pillar, and built over it an octagonal observatory with a revolving roof. When the American astronomical expedition visited Tasmania in 1874, to observe the Transit of Venus on December 9th of that year, it was natural that Alfred Biggs should become intimate with the astronomers. So highly did they think of his work that on their departure they presented him with the transit house used by them. This he set up beside his observatory. Here in Royal Park he did splendid work, winning international repute. In 1884 he contributed his first astronomical paper

to the Royal Society—" Spectroscopic Observations of Comet 'Pons'." From then on he was a regular contributor. His papers—" Report of Spectroscopic Observations of the Twilight Glows during February and March" (1884), " Tasmanian Earth Tremors" (1885), " The Star 'Alpha Centauri'" (1887), " The Occultation of Jupiter," " Is Jupiter Self Luminous?" (1886), " A New Dark-field Micrometer for Double-star Measurement," " Observations of Comet of July and August" (1889), " Recent Measures of 'A Centauri'" (1889), " The Eclipse of the Moon" (1891), " The Transit of Mercury" (1891), " The Possibilities of the Telescope" (1891)—show to some extent his activities. The main telescope he used was a fine instrument, an 8¾-inch reflector (Newtonian), which at his death he bequeathed to the Royal Society.

He took a keen interest in mechanics generally, showing remarkable skill in both theory and practice. One of the transit instruments used in his observations was made entirely with his own hands; his microscope was entirely his own work, even the lenses and eye-pieces being ground by him.

When Alexander Graham Bell discovered the principle of the telephone in 1876, he described his invention at length in " The British Mechanic." Alfred Biggs read this with interest. At once he constructed sets. Keeping one set at Launceston, he forwarded another to Campbell Town, and tried out the invention. It was a complete success, the reception and transmission being equal to those of any modern instrument. This was, I think, the first telephone used in Australia. Such an experiment exemplifies his technical skill and his keen interest in general scientific pursuits. Among other examples may be mentioned a master electric clock, 6 feet high, and accurate to the second, which drove other clocks minute by minute.

PRELIMINARY NOTES ON A ROCK SHELTER IN EASTERN TASMANIA.

By

F. Heyward, F.R.A.I.A.

(Read 25th September, 1933.)

The cave or shelter occurs in the cliff walls of the gorge of a small rivulet that is one of the tributaries of the Little Swanport River.

The creek-bed varies greatly; sometimes running through open country, and then turning abruptly and passing between freestone cliffs 80 to 100 feet high. In fact, the stream, though normally a small rivulet, appears in places to cut across the natural features of the country-side.

The shelter in question occurs just before the rivulet leaves one of the gorge sections of its course to meander through a wide, flat valley bottom of deep black soil. This valley probably fed many kangaroo when the aboriginals were wandering there. The natives did pass along it, because the writer has found many implements at the lower end of the valley, as well as along its course and far beyond the rock shelter.

It is improbable that they used the gorge section of the river-bed as a thoroughfare. At the present time it is very rough in places, and, from various indications, would then probably be choked with scrub and trees. At this day it is easy to short-circuit this rocky section, and it appears likely that the natives did this. If this is true, then it is clear why so few artefacts were found in the sand of the shelter floor.

The cave was not generally used by the aboriginals, nor was it on the main road or travel-line of the tribe. From its position it might almost have been a refuge or hiding-place—at any rate, from white settlers. It appears to have been ideal for such a purpose. At the point where the stream emerges on to the black-soiled valley bottom before mentioned the rocky gorge is running approximately north and south. If one stands on the flat facing into the opening and up the stream, he is faced with these features: on the

right a very steep, cliff-crowned hill, perhaps 150 feet high; on the left is a similar hill, but lower; these extend, respectively, roughly east and west, and are clothed with gums, wattle, and other scrub. Probably the distance across the gorge at the top of the talus-like slopes and at the base of the cliffs would be 60 to 70 yards.

Almost at the entrance the gorge is blocked by the trunks of old fallen trees and a steep rocky face, over which the stream forms a waterfall.

The shelter occurs perhaps 70 or 80 yards from the entrance and in the cliff portion of the eastern side. At this point the creek runs closer to the western bank, and there is a steep earth and rock slope from its bed up to the foot of the cliff on the eastern side; this slope is covered with scrub and tall trees.

The shelter is in the face of the eastern cliff, and thus looks west, but must have been well protected before the fires of settlers penetrated and burnt the bush.

The floor of the shelter is at varying heights from the base of the cliff, the earth sloping from north to south, and at the highest point must be 9 or 10 feet below the cave floor, whilst at the northern end the height is only 3 or 4 feet.

The shelter is naturally divided into two parts. At one end the shelf that forms the floor is about 5 feet 6 inches wide; but here there is practically no ceiling; the rock slopes from the back of the floor at a steep angle till it nearly reaches the top of the cliff. The length of this part of the cave would be 8 or 9 feet.

The portion of shelter further north has a species of ceiling, and is more in the nature of a cave. One may stand up at the outer edge of the floor, which might be 3 feet 6 inches wide. This part of the cave is about 7 or 8 feet long. The floor slopes upward from the south to the north, and leads naturally towards the cliff-top at the east side of the entrance to the gorge. At this point there is a natural lookout, giving a view through the tree-tops over the wide valley bottom mentioned before.

Returning to the shelter. There is evidence of fires having been built on the floor, for in both portions the freestone back has two clearly marked spots, where fires frequently lit have left their mark, in the shape of a change of colour in the freestone from yellow to red. Of course the erosion of the winds and damp of years have removed any trace of soot.

When the writer entered, the sand on the floor was even and smooth, except for the track of some animal, and under a little projecting ledge of rock was an abandoned nest of small sticks, &c., whilst near-by were a few whitened bones of a small animal.

On the outer edge of the part of shelter furthest north were three or four artefacts, lying as though they had been left there by the last user—one was nearly falling from the edge of the floor into the bush below. The sand of the floor at this point yielded several more—one or two buried 6 or 7 inches deep. Fine black dust and a few old pieces of burnt bone are mixed all through the sand.

Behind where the fire must have been was a small flattish stone, sized roughly 9 inches by 7 inches, and placed level and parallel with the back of the shelter. This was remarkable because of the absence of other large stones.

The artefacts are all rather small and comparatively neatly formed. Other scrapers found in the neighbourhood are much bolder in design.

The implements are interesting, as affording examples of most of the ordinary types found in Tasmania. They are as follows:—

1. Side scrapers, 3½ inches long, worked full length of one side.
2. End scraper, 2¾ inches long, worked at point (approximates to Aurignacian type).
3. Awl, worked to good point. One side may have been of service as concave scraper 2¾ inches long.
4. Stone similar to oval "oyster" or thumb stone types, though not finished on one side.
5. Roughly heart-shaped stone, top edge concave.
6. Broadened end scraper—a good edge, well chipped, rest of stone roughly shaped.
7. Nondescript stone, very thin, but with delicate chippings on edge.

OBSERVATIONS ON SOME TASMANIAN FISHES, WITH DESCRIPTIONS OF NEW SPECIES.

By

E. O. G. Scott, B.Sc.,

Assistant-Curator, Queen Victoria Museum, Launceston.

Plates VI.-VIII.; and Two Text Figures.

(Read 25th September, 1933.)

Scope.

The present paper deals with material that has come under observation in the course of Museum routine. It falls into three sections—

(*a*) Some general observations; species mentioned being *Regilophotes güntheri, Phyllopteryx foliatus, Cephaloscyllium isabella, Urolophus viridis, Anguilla reinhardtii, Solegnathus fasciatus, Galaxias affinis.* In view of the scant attention our Tasmanian fishes, except in so far as they come within the purview of general Australian ichthyology, are at present receiving, it has seemed worth while to record these notes, and, though their incidental nature is fully realised, to give them in enough detail to render them reasonably self-sufficient memoranda, available when the need for them arises.

(*b*) Additions to the Tasmanian list: *Exonautes cribrosus, Solegnathus robustus.*

(*c*) Descriptions of a new species of *Galaxias*, and a new species of *Agrostichthys*, the latter, incidentally, constituting the first Australian record of the family Agrostichthyidæ.

Except where otherwise stated, the registration numbers are those of the Queen Victoria Museum, Launceston, Tasmania.

Regilophotes güntheri (Johnston).

Lophotes güntheri Johnston, Pap. and Proc. Roy. Soc. Tas., 1882 (1883), pp. xlv., 142, and 176.

Regilophotes güntheri (Johnston), Whitley, Rec. Aus. Mus., XIX., I., Aug., 1933, p. 72.

Johnston's type of *Lophotes güntheri* was obtained "near Emu Bay," North-Western Tasmania. A contemporary news-

paper account of it, *ex* Johnston MS., has been made available by Whitley (1928, p. 50).

Australian and New Zealand records of Lophotidæ are few, Whitley (1933, p. 72) is of the opinion that the New Zealand records (Waite, 1914) of *Lophotes cepedianus* and *L. fiskii*, and the Victorian record (Kershaw, 1909) of *L. cristatus* Johnson, a Madieran species, probably all refer to Johnston's *L. güntheri*. Remarking that "the very distinct Australian genus evidently requires a new name," he institutes *Regilophotes* gen. nov.: orthotype, *Lophotes güntheri* Johnston, 1883.

A topotypical specimen of *Regilophotes güntheri* (Johnston) is in the Australian Museum, Sydney; Regd. No. B. 5776 (*fide* Whitley).

As any particulars relating to this rare fish are of interest, I give below such information as I have been able to collect on a topotypical specimen caught, on rod and line, at Cooee Creek, near Burnie, by Mr. P. Saunders, on 23rd September, 1931, and forwarded, through the kind offices of the late R. S. Sanderson, to the Museum. Unfortunately, the specimen, which had been exhibited for some time in a fish-shop, was found by the taxidermist to whom it was handed on its arrival to be beyond preservation.

In a letter dated 1st October, 1931, acknowledging the receipt of some observations on, and measurements of, the specimen, Mr. Sanderson made the following interesting comments:

> "The close approximation to each other of the 1882 and 1931 specimens is very striking, but apart from that I can say positively that the two specimens might well be regarded as merely two units of a mass-production so much do they resemble one another. I saw the 1882 specimen on the rocky beach—about opposite the present Burnie Hotel—very shortly after some lads had discovered it (if I remember rightly it was not caught—at least, not by hook and line, and where it was lying was no place for a seine net), and have always retained a clear mental impression of its remarkable appearance. Consequently I had no hesitation in identifying the fish when called downstairs to look at the strange creature which some boys had brought in."

Speaking of the degeneration of the specimen through keeping, Mr. Sanderson observed:

> "When first caught, the brilliant silvery gleam largely overpowered the salmon pink look which it had next day.

The eye when fresh was a beautiful object—of great depth and luminosity—more like that of some animal (the 'mild eyed kine' of the classics, for instance), and the dorsal fin was well defined."

On its arrival in Launceston, the fish was in general colour a rich pink or red, frosted over with sheer silver. In some regions the silver was dominant, being scarcely influenced at all by the underlying red; in others the rich background blushed through the argentine wash; the net effect being now that of silvered purple, and now that of purpled silver. This pomp of general body-colour was elegantly relieved by the lustrous brown-black of the head-region (particularly the opercle) and by the limpid dark-brown of the eye.

Some dimensions of the 1931 specimen (with corresponding measurements of the 1882 specimen in parentheses): Length, 44 inches (43¾ inches); depth behind shoulder, 8⅝ inches (7¾ inches); length of pectoral ray, 2 inches (2¼ inches); diameter of eye, 2 inches (2 inches); greatest thickness of body, 1¾ inches (1⅝ inches).

Phyllopteryx foliatus (Shaw).

Syngnathus foliatus Shaw, Gen. Zool. (Pisc.), V., 2, 1804, p. 456, Pl. clxxx. (*fide* Sherborn).

Phyllopteryx foliatus Günther, Cat. Fish. Brit. Mus., VIII., 1870, p. 196; *id.*, McCoy, Prod. Zool. Vict., dec. VII., 1882, pp. 19-20, Pl. lxv., Figs. 1, 1a, 1b.

Phyllopteryx altus McCoy, Prod. Zool. Vict., dec. VII., 1882, p. 20.

(Text Figure 1.)

McCoy (1882) described and figured *Phyllopteryx foliatus* as having two small tags depending from the ventral surface of the snout. He notes (p. 19) the occurrence of "two minute spines on upper edge of snout, considerably nearer to the eye than the tip, and two slender filaments (often united) on under opposite side"; and his natural size, coloured representation of a "moderate specimen" (Pl. 65, Fig. 1) depicts these tags as two separate brown ribbon-like appendages, in the position described, and measuring, roughly, 7 mm. long and 0·5 mm. wide.

The presence of these tags has not, I think, been recorded by any other observer; and Waite and Hale (1921), in reviewing the Lophobranchiate material of the South Australian Museum, state (p. 315): "The small tags, as figured

by McCoy, beneath the snout, are not present in any specimen we have seen."

In a specimen (Reg. No. 952) netted at Stanley, North-West Coast, by Mr. T. B. Smith on 2nd October, 1932, one of these tags occurs, plastered on to the right side of the snout. Length, about 10 mm.; colour, black. Though quite narrow proximally, it expands distally to a width of about 2·5 mm.; its general shape suggesting a stalked, narrowly ovate-acuminate leaf. It would hardly be described as a "slender filament": though this expression applies quite well to the appendage as figured by McCoy. (See Text Fig. 1.)

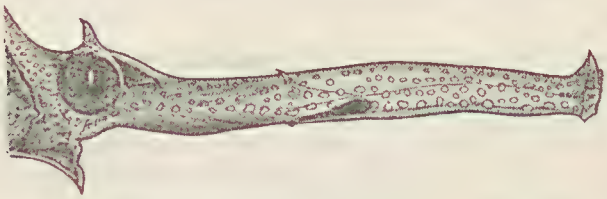

Fig. 1. *Phyllopteryx foliatus* (Shaw): Snout, showing Tag. (About natural size.)

An examination of this and other Tasmanian specimens suggests the following additions to, and enlargements upon, the excellent description of the species given by Waite and Hale.

Small spine on the nape, about midway between the occipital and nuchal appendage-bearing spines; sometimes a second, smaller, more anterior spine. Of the two small spines on the upper surface of the snout, one is commonly in advance of the other. "A small" bifid "spine on the front edge of the orbit." "A small patch of bristle-like spines below the hinder part of the orbit and a row of spines on the lower edge of the eye occasionally present," the bristle-like patch regularly including, in Tasmanian specimens, at least one conspicuous backwardly directed spine. Sometimes a row of small spines running forward along the supraorbital ridge from the two large supraorbital spines (which may be secondarily spined, and may have small spines round their bases). Occipital spine commonly with four distal spikes. Spines on dorsal body-ridge "strongest alongside the fin and almost obsolete on the dorsal arch," but usually well developed in advance of the latter. Of the spines on the paired ventral body-ridges, that of the antepenultimate body-annulus is much stronger than any others,

and is generally serrated; and that on about the fourth body-annulus is larger than its neighbours. "A pair of spines in front of the lower half of each pectoral base," with occasionally several smaller spines between them and the fin. Two or three spines above superior margin of preoperculum, that situated nearly below the appendage-bearing occipital spine being the largest. The inferior nuchal region in advance of pectorals, which McCoy describes as "swollen conically," tends to form, in dried specimens, a subrectangular platform: this bears spines at its posterior angle (commonly two pairs), at its anterior angle (one pair), and occasionally along the longitudinal diagonal (several rows; spines small). Total length reaches 388 mm. Appendage-bearing spines may be spotted or blotched with lighter colour, these spots and blotches being, like those on snout and elsewhere, translucent in dried specimens.

All the Tasmanian specimens that have come under my notice are of the deep-bodied type, in which the greatest depth of the body is equal to or exceeds the length of the snout, or the equivalent of about 10 body-rings, as against barely 0·75 of the length of the snout, or the equivalent of about seven body-rings, as in Shaw's original figure of *S. foliatus*. McCoy's *P. altus*, which is based on this feature, and on the marked difference in colour between the Victorian specimens, as shown in his own plate of *P. foliatus*, and the Tasmanian specimens, as shown in the painting by Mrs. Meredith (1880), has now been merged, seemingly with pretty general consent, with *Phyllopteryx foliatus* (Shaw): it is possible, however, that a survey of an adequate series of Tasmanian and mainland specimens might establish the validity of McCoy's species.

Cephaloscyllium isabella (Bonnaterre).

Squalus isabella Bonnaterre, Tabl. Encycl. Meth., Ichth., 1788, p. 6.

Scyllium laticeps Duméril, Rev. et Mag. Zool. (2) V., 1853, pp. 11 and 84, Pl. iii, Fig. 2 (head).

Cephaloscyllium isabella Gill, Ann. Lyc. Nat. Hist.; N. York, VII., 1862, p. 412.

In dealing with *Cephaloscyllium isabella*, Lord and Scott (1924, p. 22), after giving "Reference:—Waite, Trans, N.Z. Inst., 1909, XLIX., p. 384; McCulloch, 'Endeavour' Scientific Results, 1911, p. 6"—observe: "Recorded by McCulloch

from East Coast of Flinders Island, Bass Straits." McCulloch (*loc. cit.*) states: "A small example is in the collection which was trawled off the east coast of Flinders Island, Bass Strait."

As Lord and Scott's synopsis constitutes the most recent revision of the fish-fauna of Tasmania, and will form, it may be presumed, the basis for future work, it is perhaps worth while to call attention to the fact that this species, as *Scyllium laticeps*, is accredited to Tasmania by Günther (1870, p. 404), and appears in Johnston's list of 1882 (p. 138) and 1890 (p. 39).

It is apparently fairly common in Tasmanian waters. A specimen, having a total length of 885 mm., was secured in a graball at Penguin, North-West Coast, by Mr. W. J. Beaumont, on 18th June, 1933, and was received at the Museum (Reg. No. 964) the next day. It may be remarked, in passing, that this shark, after having travelled to Launceston by train in a sack, exhibited distinct evidences of life while being examined, and on being placed in fresh water at 4.15 p.m. on 19th June, revived sufficiently to breathe quite regularly and to move the pectoral fins and the tail. A specimen, 961 mm. in total length, was found by me washed up on the beach at Ulverstone, North-West Coast, on 4th August, 1933. Mr. J. A. Begent, B.Sc., informs me that this shark is frequently met with at Stanley, North-West Coast, where it is commonly referred to as the "Nurse" or "Grey Nurse"—a rather unfortunate vernacular name in view of the well-established association of "Grey Nurse" with species of *Carcharias*, including our own *C. arenarius*.

Urolophus viridis McCulloch.

Urolophus viridis McCulloch, Biol. Res. "Endeavour," IV., 4, 1916, p. 176, Pl. li.

It is of interest to note the presence in the Museum of an Old-Collection spirit-specimen (Reg. No. 971a) of this species, dating back at least 36 years, and originally determined as *Narcine tasmaniensis*. Total length, c. 197 mm.; disc-width, c. 123 mm.

Anguilla reinhardtii Steindachner.

Anguilla reinhardtii Steindachner, Sitzb. Akad. Wiss. Wien, LV., I., 1867, p. 15, Figs. a-b.

Anguilla marginipinnis Macleay, Proc. Linn. Soc. N.S. Wales, VIII., July 17th, 1883, p. 210.

Anguilla reinhardtii is not included in either of Johnston's lists; and Günther (1870, p. 27) gives as its range "Northeastern Australia."

This species is, however, accredited to Tasmania by Lord (1922, p. 64), Lord and Scott (1924, p. 36), and McCulloch, "Rivers of Eastern Australia (Queensland to Tasmania)" (1929, p. 64); but on just what records these attributions are based I am unable at the moment, through lack of literature, to determine.

On the other hand, Schmidt (1928) says of *A. reinhardtii* (p. 193): "in Tasmania it has not yet been observed"; and in his chart of "Distribution of the Australian eels according to the examination of a number of samples consisting of about 900 specimens" (Fig. 13) he also represents our only species as being *A. australis*. Among the 928 specimens of *Anguilla* examined by Schmidt were "51 from Tasmania, including Flinders and Vansittart Islands" (p. 192).

In view of the element of uncertainty introduced by the statement of so eminent an authority on the genus *Anguilla* as Schmidt, the following facts seem worthy of record.

In the Museum are three long-finned eels from Longford, 20.3.1908; Cataract mill-race, Launceston, 25.8.1908; and "near Launceston," 1928 (Reg. Nos. 946, a, b, and c). These specimens, which were preserved on account of their unusually large size, measure 1635, 1525, and 1531 mm. in total length.

In 1932 I brought these specimens under the notice of Professor Schmidt, and forwarded to him a note on their $\frac{a-d}{t} \times 100$ values (a = length to vent; d = length to origin of dorsal fin; t = total length). The factors for these three specimens are, as nearly as can be determined, 11·4 (a = 688 mm., d = 501 mm., t = 1635 mm.), 11·2 (a = 647 mm., d = 476 mm., t = 1525 mm.), and 10·8 (a = 682 mm., d = 517 mm., t = 1531 mm.). Schmidt determined the $\frac{a-d}{t}$ percentages for *A. australis f. occidentalis* as from − 1·5 to + 4·0, average 1·27; and for *A. reinhardtii* as from 7·8 to 13·2, average 10·72.

Concerning these eels, Professor Schmidt remarked (*in litt.*): "From the $\frac{a-d}{t} \times 100$ values stated by you, I have no doubt that the specimens really belong to this species" [*A. reinhardtii*]. At the same time, he called attention to the possibility of *A. aucklandi*, whose known range is sur-

prisingly restricted, reaching our waters, stating: "There seems to be reason to keep a sharp look-out for this species in Tasmania."

Without an anatomical examination, there is little to distinguish *A. reinhardtii* from *A. aucklandi*. On the whole, however, the evidence afforded by external features and teeth seems to indicate that the present specimens are to be relegated to the former species.

Unfortunately the death during the present year of Professor Schmidt prevented the completion of an arrangement I had entered into with him to submit for his detailed examination a further series of Tasmanian specimens.

Fishermen inform me that both *A. reinhardtii* and *A. australis* are common in Tasmania, the opinion commonly being held that the distribution depends upon the nature of the river, either as a whole or in given sections, the former species preferring a sandy or gravelly, the latter species a muddy, bottom.

In his paper cited above Schmidt remarks (p. 193): "It would be useful in the work of further research if zoologists or other interested parties in Australia would endeavour to ascertain the length and weight attained by *Anguilla reinhardti*." After quoting reports of eels up to 30 lb. in weight from "Eastern Victoria," and of up to 20 lb. from the Tambo River, East Gippsland, Victoria, he observes: "It will be apparent from the above that I have not personally seen any specimens of *Anguilla reinhardti* over 135 cm. in length and 6·7 kilograms in weight. It is most likely, however, that the larger eels, of 20 or 30 lb. weight, noted above belong to this species rather than to *Anguilla australis*. In any case, it is remarkable that eels of this size should be specially noted as occurring only in the eastern part of the State of Victoria, for *Anguilla australis* is, as we have seen, extremely common also in the western part."

The three Museum specimens of *A. reinhardtii* have, as already noted, a total length of 1635, 1525, and 1531 mm., as preserved. The register records that the weight of the Longford specimen (Reg. No. 946a) was 34 lbs.; of the Cataract mill-race, Launceston, specimen (Reg. No. 946b) 28 lbs.; while the weight of the specimen from "near Launceston" (Reg. No. 946c) is entered as "said to be 42 lbs."

It should be observed that Johnston (1883) says of *Anguilla australis*, "Reaches to an immense size in the South

Esk River" (p. 133); and, again, "Some of the eels have been taken in the Ringarooma and South Esk Rivers over 30 lbs. in weight and over 20 inches in girth" (p. 61).

Mr. I. Tyler, fishmonger, Launceston, informs me that there passed through his hands, during the latter half of 1932, a short-finned eel, caught at the Power Station, South Esk River, near Launceston, that measured about 5 feet in length, and weighed 36 lb.

Solegnathus fasciatus (Günther).

Solenognathus fasciatus Günther, Rept. Voy. "Challenger," Zool. I., 6, 1880, p. 30, Pl. xiv., Fig. B.

The locality of this species, the type of which was secured by the "Challenger" off Twofold Bay, is given by McCulloch (1929) as New South Wales.

Its appearance in the Tasmanian lists of Lord (1922) and Lord and Scott (1924) is apparently based on the collection by the "Endeavour" of specimens "South-east from Babel Island, off Flinders Island, Bass Strait" (McCulloch, 1911).

In these circumstances, it may be noted that the Museum collection includes a specimen (total length, c. 350 mm.) from Scamander, East Coast (Reg. No. 951z).

Galaxias affinis Regan.

Galaxias affinis Regan, Proc. Zool. Soc., Lond., 1905, II., (April 5th, 1906), p. 380, Pl. x, Fig. 1.

This species (type-locality, Lake St. Clair) is omitted from the published Tasmanian lists, all of which are in need of revision.

Exonautes cribrosus (Kner).

(Exocoetus) cribrosa Kner, Reise Novara, Fische, III., 1867, p. 328. Alternative name of *E. unicolor* Kner, regarded as possibly distinct from *E. unicolor* Cuvier and Valenciennes, (*fide* McCulloch, 1929).

Exonautes fulvipes Ogilby, Proc. Roy. Soc. Qld., XXI., 1908, p. 8.

On the afternoon of Tuesday, 13th May, 1930, a live flying-fish was captured at West Bay, River Tamar, by Mr. R. S. Allison, who in a covering letter says: "I was standing near the beach when the fish rose from the water and flew

a short distance, when the strong southerly wind threw it back on the rocks, where I ran and caught it."

The specimen, which has a total length, as a formalin preparation, of approximately 295 mm., appears to be a fairly typical example of *Exonautes cribrosus* (Kner). Reg. No. 975.

First record of the species—and, *fide* McCulloch (1929), of the family Exocoetidæ—for Tasmania.

Solegnathus robustus McCulloch.

Solenognathus spinosissimus Zietz, Trans. Roy. Soc. S. Aus., XXXII., 1908, p. 299 (not of Günth.).

Solegnathus robustus McCulloch, Zool. Res. "Endeavour," I., 1911, p. 28, Pl. ix., Fig. 2.

This species was described by McCulloch from a single specimen "from 37 fathoms off Flinders Island, South Australia, August 30th, 1909." Waite and Hale (1921), who regard the South Australian specimens determined by Zietz (1908) as *Solenognathus spinosissimus* Günther as belonging to this species, state (p. 313): "Specimens are known from Corney Point, Pt. Lincoln, and Flinders Island [i.e., Flinders Island, S. Aus.], the longest being 364 mm."

The present notice of a dried specimen from Blue Rocks, Flinders Island, Bass Strait (Reg. No. 953), constitutes the first record for Tasmania.

It is perhaps as well to point out that the present note in no way affects *Solegnathus spinosissimus* (Günther), the position of which on our list is well established: a specimen of this species from Tamar Heads is in the collection (Reg. No. 952).

In dealing with *S. robustus*, Waite and Hale point out that whereas McCulloch (1911) gives the head as "3·7 in the trunk," his figure shows 2·7 is intended: in the present specimen the value is only 2·4. McCulloch says, "Length of tail a little less than the distance between the vent and the pectorals": but Waite and Hale observe, "The length of the tail is subject to slight variation; in two of our examples it is less than the distance between the vent and the pectoral fin, in the third it is as long as the trunk." In the Tasmanian example the tail is 1·08 times the trunk. As, however, the trunk is relatively shorter in this specimen than in the others described, the tail is not significantly

longer, relative to the total length, than in McCulloch's specimen, the ratio in that case, calculated from the other proportions given, being 2·3 (2·31), and in the present instance 2·4 (2·37).

The greater relative depth of the snout, and of the tail immediately behind the dorsal fin; the radiating rows of spines on the scutes; and the more imperfect attainment of the dorsal profile by the main lateral row of spines (an attainment delayed, in the specimen, till about the twenty-fifth caudal annulus)—the chief characters that serve to distinguish this species from *S. fasciatus*—are well marked in the present specimen. The length of the base of the dorsal fin, which McCulloch gives as "almost equal to the distance between the tip of the snout and the posterior border of the eye," is here 0·98 of that distance; while, it may be observed, the corresponding value in the case of *Solegnathus fasciatus*, determined from the specimen from Scamander, previously mentioned, is only 0·79.

Total length of specimen, 358·5 mm.

Family GALAXIIDÆ.

Genus GALAXIAS Cuvier, 1816.

Galaxias Cuvier, Regn. Anim., ed. 1, II., "1817" = Dec. 1816, p. 183. Haplotype, *Esox truttaceus* Cuvier.

GALAXIAS CLEAVERI, sp. nov.

[Plate VI.]

(a) History of the Specimen.

The history of this specimen is of some interest, both in itself and for the incidental light it throws upon the habits of the Galaxiidæ generally.

On the 23rd December, 1932, a eucalyptus stump, about 2 feet through, was blown out of the ground by explosives at West Ulverstone, North-West Coast, and on cutting up some of the wood for household purposes on 8th January, 1933, Mr. F. Cleaver found the fish in a root about 8 inches in diameter. The root, which was just damp, contained a cavity, in the middle of which the fish was lying. Mr. Cleaver says he has no idea how it got into the log, which was prone on the surface of the ground. He states: "There is no running water for about a quarter of a mile, but all through the

winter there is water lying in ponds close to where the stump stood in swampy ground."

The fish was kept alive in a tin of water, the tin being sunk in the garden, with the top flush with the ground. On one occasion, the specimen, which was always prone to jump out of a vessel in which it was placed, was missing from its tin, and was later found happily wandering about, some distance away, among the tomato-plants. While in its discoverer's possession, its longest spell out of water was 12 hours. As far as Mr. Cleaver is aware, no other fish of the same kind has been met with in the vicinity.

At the suggestion of Mr. H. Rodman, the fish was secured for the Museum. It was forwarded from West Ulverstone, by service car, in a bottle of water, and came to hand alive on Tuesday, 4th April, 1933.

On its arrival at the Museum, it was transferred to a bucket filled to a depth of about 4 inches with tap-water, in which were placed bread-crumbs—an item of diet to which Mr. Cleaver had found it readily took. During the afternoon it was placed on a table, where it remained, occasionally leaping, at no great height, for a distance of several inches, for seven minutes, every now and again gulping in a mouthful of air. Though it exhibited no marked signs of distress, retaining the normal upright position without difficulty, it is of interest to note that, seven minutes after it was returned to the water, its rate of respiration was 42 per minute, whereas in another eight minutes the rate had increased to 56.

After being kept alive in its bucket for just over a week, the specimen was embedded at 2.30 p.m. on Wednesday, 12th April, in well-moistened earth, where it remained for three-quarters of an hour, apparently without suffering any discomfort, but becoming decidedly darker in general colour in harmony with its surroundings. At 3.15 p.m. it was taken out of the damp earth, washed, drained of excess moisture, and placed in a perfectly dry watering-can, the top of which was covered with newspaper perforated with several holes.

When examined the next morning, Thursday, at 9 o'clock, it was still very evidently alive, but apparently disinclined to make much movement. On being taken up, however, it at once began to move in very lively fashion—being excited, very possibly, by the warmth of the hand—and, when placed on the table, continued vigorously to leap about. After a few moments it was returned to its can.

On Friday morning the fish was still obviously alive, but during the day it began to shrivel up. By Saturday morning, at 9 o'clock, it presented much the appearance of a dried-up worm, the whole body being shrunken and wrinkled. As, after repeated tests, it gave no obvious evidence of life, it was placed in formalin. Immediately on coming into contact with the liquid, it revived, and demonstrated its vitality by several vigorous plunges, only to be overcome, in a few moments, by the preservative.

In this test, therefore, the fish first remained alive for three-quarters of an hour in damp soil. It then lived in a dry vessel from Wednesday, 12th April, at 3.15 p.m., till Saturday, 15th April, at 9 a.m.—i.e., for 65¾ hours. Even then, as has been noted, it was not dead, but, as events proved, merely very quiescent. It seems not at all unlikely that had the fish been kept even barely moist, it might have survived for a longer, possibly much longer, period.

(b) Ability of the Galaxiidæ to Live Out of Water.

The New Zealand *Neochanna apoda*, of course, burrows in damp clay, and it has been stated that it soon dies if placed in clear water.

T. S. Hall (1900) gives an account of a burrowing *Galaxias* from Strahan, Tasmania, found in "decayed peat and sand, eight inches below the surface." The only description given of the fish, the species being undetermined, is as follows: "It is a slender form, and is marked by chevron-shaped dark bands of small spots, which mark out the myotomes in the middle of the body, but become irregular towards the head and tail. Its total length is 44 mm." He also notes: "Fish are reported as being occasionally dug up in the button-grass country, on the west coast of the island, and are stated by a miner to have no eyes, though otherwise similar."

I have spoken with several people who have encountered this burrowing *Galaxias* on the West Coast; but I have not so far been able to secure a specimen. I am informed that about 30 years ago numbers were dug up in the grounds of the State school residence at Strahan.

It seems not unlikely that our little native trout generally, living as they often do in small creeks that periodically become partly or wholly dry, have been driven by the conditions of their existence to acquire, to a greater or lesser extent, the power of burrowing and the ability to survive

for considerable periods in damp earth. Mr. R. Slater, of Kelso, informs me that a *Galaxias* is sometimes met with on his estate, some distance below the surface in dried-up waterholes.

That native trout will frequently revive on being thrown into water, after lying for some hours in a bag or basket, is a fact with which many fishermen are familiar. A specimen of *Galaxias truttaceus*, placed in the dry vessel used previously in the experiment with Mr. Cleaver's fish, was found to be very much alive after 19 hours. On being supplied with water, it opened its gill-covers widely, and in about a minute was swimming round blithely, and breathing in normal fashion. If its degree of vitality after 19 hours afforded any criterion, it would probably have survived in the dry state for a considerably longer period. Further experiments along similar lines on the various members of the genus would probably throw much interesting light on their habits.

(c) Description: Galaxias cleaveri, sp. nov.

General form, moderately stout, subcylindrical.

Depth of body (14·2 mm.), 8·4 in total length (119 mm.), or 7·6 in standard length (108 mm.). Length of head (17·5 mm.), 6·2 in standard length. Eye small, its diameter (2·5 mm.) 8·8 in length of head, or 2·0 in length of snout (5 mm.), or 2·4 in interorbital width (7 mm.). Teeth in the jaws subequal, except for one enlarged lateral canine in each side of lower jaw. Lower jaw projecting; maxillary extending to below anterior third of eye. Branchiostegals, 9.

Dorsal III + 8; the length to its origin (76 mm.) 4·0 times length to origin of pectoral (19 mm.), or 2·1 times space between base of pectoral and origin of ventral (37 mm.): distance from origin of dorsal to end of caudal peduncle (32 mm.) 3·7 in total length: length of base of dorsal (14 mm.) twice interocular distance, or nearly equal to greatest depth of body. When laid back, dorsal reaches beyond superior procurrent caudal rays, but only to level of inferior procurrent caudal rays.

Anal III + 7; its origin (82 mm. behind snout) behind the origin of dorsal by 1·2 times length of snout, or by 0·75 of depth of caudal peduncle; its base (13 mm.) 1·08 times base of dorsal. When laid back, anal reaches about

to middle of inferior length of caudal peduncle, and extends behind laid-back dorsal by a distance equal to length of snout.

Pectoral with 14 rays; its length (11 mm.) 0·6 of length of head, or 2·2 times length of snout; extending 0·3 of the distance from its base to base of ventral.

Ventrals 6-rayed; their origin (56 mm. behind snout) about equidistant from anterior margin of eye and base of caudal, or about equidistant from base of pectoral and posterior sixth of base of anal; their length (8·5 mm.) rather less than half length of head, or 2·2 in distance between their origin and origin of anal.

Caudal with 22 major rays; rounded subtruncate, its most posterior point being (in alcohol-specimen) 3·6 mm. (i.e., rather more than half distance from tip of snout to posterior margin of eye) behind the vertical joining its postero-superior and postero-inferior angles. Superior procurrent rays of caudal begin 1·5 mm. behind base of dorsal, or 91·5 mm. behind snout; inferior procurrent rays begin immediately at distal end of base of anal, with which they are just continuous, or 95 mm. behind snout. Hence superior length of caudal peduncle (16·5 mm.) is 2·1 times depth of caudal peduncle, or 1·3 times length of base of anal, while inferior length (13 mm.) is 1·6 times depth of caudal peduncle, or equal to base of anal.

In life, general colour olivaceous, subtranslucent; under-surface in advance of ventrals greyish, behind ventrals greyish-green, immaculate. Snout dark-brown; rest of head, except ventral surface, which is greenish-yellow minutely and sparsely dotted with brown, is heavily blotched with brown, especially dorsally. Sides of body heavily barred and blotched with dark-brown; bars about 22, irregular, but tending to form forwardly directed chevrons with apex near midlateral line, bases of bars with irregular prolongations giving a somewhat reticulated effect, bars about equal in width to their interspaces; between and below bars some irregular blotches. Dorsal surface like lateral surface, but with more brown, the bars showing marked tendency towards confluence. Pectorals light greenish-grey, darker in proximal third. Dorsal, anal, and ventrals greyish or yellowish green, darker in proximal half or more. Caudal greenish, with dark spot at base. In the preserved specimen the ground colour has become opaque, and more yellowish olivaceous.

(d) Remarks.

The present species is distinguished from all the described Australian species in having the caudal rounded subtruncate. In general appearance, though not in size, it perhaps more closely approaches the South African *G. zebratus* than any other species; but apart from the improbability, on the grounds of distribution, of it being conspecific with this form, it is readily distinguishable from it by such characters as presence of enlarged lateral canines, much more backwardly placed dorsal, smaller pectorals, shorter head, &c.

It differs from all the Australian species, except *G. dissimilis*, in having 6-rayed ventrals. From *G. dissimilis*, the first published figure of which anomalous form has just been made available by Whitley (1933, Pl. xii., Fig. 2), it is at once separated by the normal, more forward position of the ventrals, size of the pectoral, character of teeth, &c.

In general form and in colouration it closely approaches *G. weedoni*. From this species it is distinguished chiefly by the rounded subtruncate caudal, different number of rays in the dorsal, anal, and ventral, shorter pectoral and ventral, projecting lower jaw, and smaller eye.

The extremely small size of the eye, the diameter of which is 8·8 in the length of the head, is remarkable: the average value of this ratio for the Australian species is about 4·7, the maximum (*G. affinis*) 5·5. According to Tate Regan (1906), the value for *Neochanna apoda* is 6-8. To what extent, if at all, the minute size of the eye might be correlated with the individual history of the specimen, it is difficult to say.

The ventrals are relatively small. The length of these is not regularly recorded in specific diagnoses: judging from figures, however, it would seem that their length is seldom, if ever, contained in the total length more than about 12 times, the average value being apparently about 9·5. In the present specimen this value is 14. Again, it is difficult to determine the likelihood of this being an individual character.

While it is with some diffidence that I venture to create, on the strength of a single specimen, a new species in a family so variable as the Galaxiidæ, this seems to be, on the available evidence, the only honest course, and is accordingly followed.

The species is named in honour of Mr. F. Cleaver, West Ulverstone, the collector of the specimen.

Described and figured from the unique holotype in the collection of the Queen Victoria Museum, Launceston, Tasmania; Reg. No. 938 HT.

Suggested vernacular name, Cleaver's Jollytail.

Family AGROSTICHTHYIDÆ.

Genus AGROSTICHTHYS Phillipps, 1924.

Agrostichthys Phillipps, Proc. Zool. Soc., Lond., 1924, II., p. 539. Haplotype, *Regalecus parkeri* Benham.

AGROSTICHTHYS BENHAMI, sp. nov.

[Plates VII. and VIII.; Text Figure 2.]

(a) Description.

General form very elongate, and very compressed; ribbon-like.

Greatest depth of body (17·5 mm.), which is immediately behind head, 46·3 in total length (811 mm.), or 46·2 in standard length (808 mm.). Depth at vent (14 mm.) 57·9 in total length. Thickness at greatest depth (6·6 mm.) 2·7, at vent (5·2 mm.) 3·4, and at distal end of body (0·9 mm.) 19·4 in greatest depth. Length of head (38·5 mm.) 21·1 in total length, or almost twice height of head (19·3 mm.). Eye large, its horizontal diameter (9·5 mm.) 1·7 in length of snout (16·2 mm.), which is 2·4 in length of head; about 1·5 times as far from maxillary plate as from dorsal profile of head. Preanal region (252 mm.) 3·2 in total length.

Upper profile of head gently and evenly convex. Actual length of maxillary plate (12 mm.) 1·6 times its actual width (7·6 mm.), but its horizontal extent (11·4 mm.) 1·2 times its vertical extent (9·3 mm.); plate with conspicuous striæ, those on anterior half forwardly concave, those on posterior half backwardly concave, the two sets divided in their superior third by a vertical subtriangular pit, and, behind it, a backwardly concave sulcus. Similar striæ on operculum, radiating from antero-superior angle; on suboperculum, radiating from antero-superior angle; on preoperculum, becoming distinct near the middle from a median sulcus that occupies most of the narrow anterior half or more, and fanning out distally; on interoperculum, running backwards and somewhat downwards.

Dorsal III (?) + c. 400. Three long, pale golden rays in crest-like nuchal section of dorsal; first 108 mm. long (i.e., 2·8 times head, or 2·3 in preanal region), second 70 mm., third 102 mm.; with nodes, placed irregularly (at least, in preserved specimen), clustered round with minute brownish pigment-spots, 3 nodes being traceable on first ray, 7 on second (where pigmented regions about equal their interspaces), 2 on third. As it is possible some of these filaments may be lost, the number is queried: I can, however, find no definite indication of the previous presence of others. In second section of dorsal there are 374 rays up to within 35 mm. of posterior end of body, beyond which point actual count is impracticable: calculation gives 401 as total. Rays to level of vent, 103. Membrane reaches to tip of rays, longest of which is 11 mm. Rays with small spine at base, and with a single linear series of 20-30 microscopic spines, on button-like supports, along each of the two flattened surfaces.

Pectoral with 8 rays; length 9 mm.; supported on basal lobe 3 mm. long, less than 1 mm. high.

Ventrals represented by two very low ridges, about 5 mm. long, contiguous and flush with body in front, diverging and rising behind to end in two subtriangular knobs, directed downwards and outwards; each knob, 1·25 mm. high, with two spine-like projections, of which the antero-internal is the larger. Knobs 5·5 mm. behind level of posterior end of base of pectoral. By moving the ridges, one or two longitudinal slits are disclosed at the base of their external walls. The specimen affords no evidence as to whether the knobs ever bore long rays, like those of *Regalecus;* nor, if so, how many.

The body of the specimen ends posteriorly in a vertical line, 1·7 mm. high, from both the superior and inferior ends of which runs back a free filiform process 3 mm. long. It is difficult to determine from the specimen whether, on the one hand, the extreme tip of the body is damaged, the threads being merely remnants of the body-wall, or whether, on the other hand, the body is intact, the threads relating to the caudal fin: the latter alternative, though not definitely established, has for convenience been selected in determining the length of the fish.

Lateral line appears externally as a ridge, more or less semicircular in section. Originates behind postero-superior angle of operculum; swings down, touching tip of longest ray

of pectoral, in a gentle, forwardly convex curve, to a point 40 mm. behind head, and below 28th ray of major section of dorsal, where it is 2 mm. above ventral margin of body; thereafter extends caudad virtually parallel with, but actually imperceptibly and continuously approximating to, ventral margin, its distance from which, at a point 25 mm. from posterior end of body, is 0·75 mm.; hence average distance of horizontal portion of lateral line from ventral margin is about 1/6th depth of body.

Near anterior end of each lower jaw, two small, closely opposed, conical teeth, directed backwardly; no teeth in upper jaw; a single elegant median vomerine tooth, about 2·5 mm. long, with five cusps, central cusp longest, directed somewhat backwards from the plane of the two pairs of lateral cusps, the proximal pair of which is the larger; beside and behind the median vomerine tooth, one delicate simple conical tooth, on each side. (See Text Fig. 2.)

Fig. 2. *Agrostichthys benhami*, sp. nov.: The Vomerine Teeth. (About twelve times natural size.)

Mouth protractile to rather more than 1/5th length of head.

General colour (in formalin) greenish silver; body marked by faint dingy vertical bands, averaging 10 mm. wide and 40 mm. apart, formed by sparsely sprinkled brown pigment-cells; similar pigment-spots occur along whole superior margin of body. Head greenish; upper and lower lips narrowly margined with dark-brown; narrow bar of dark-brown behind, and parallel with, maxillary plate, continuous over dorsal surface of head with its fellow on the other cheek; some dark-brown elsewhere on top of head. Iris black, minutely but abundantly speckled with pale-green; pupil

green. Membrane of dorsal fin colourless, with occasional irregular patches of dingy-orange. Pectoral fin pale-green.

Scaleless. Body everywhere covered with subcircular cushion-like structures, 0·6-0·9 mm. across, interspaces 0·1-0·3 mm.

It is with pleasure I associate with the present species the name of Professor W. B. Benham, whose description of his *Regalecus parkeri* provides the first account of a representative of the interesting family Agrostichthyidæ.

Described and figured from the unique holotype, from Ulverstone, North-West Coast, Tasmania, in the collection of the Queen Victoria Museum, Launceston, Tasmania (Reg. No. 906 HT).

Suggested vernacular name, Benham's Streamer-Fish.

(b) General Remarks.

Benham's type of his *Regalecus parkeri* was washed ashore in Deborah Bay, near Port Chalmers, in Otago Harbour, New Zealand, in or about November, 1902. In an addendum to his paper, Benham (1904) noted the capture at Stewart Island of a second example, 75 inches long. Phillipps (1924) recorded a specimen, approximately 9 feet long, secured at Island Bay, Wellington, New Zealand, in July, 1921. No other records have come under my notice. According to McCulloch (1929) and Whitley (1933), the genus *Agrostichthys* has not hitherto been recorded for Australia. The specimen here described was obtained at Ulverstone, North-West Coast, Tasmania, by Mr. H. G. K. Wells, and was donated to the Museum on 14th February, 1908.

The creation by Phillips of a new genus, *Agrostichthys*, and a new family, Agrostichthyidæ, for Benham's *Regalecus parkeri* marks an important step towards a satisfactory arrangement of the Australasian Allotriognathi. Genus *Agrostichthys* Phillipps, 1924; "Body enormously elongated to 22½ times length of head; nearly 42 times greatest depth and 45 times depth at vent; 390 to 525 dorsal fin rays; teeth on head of vomer and on lower jaw; ventral reduced to a single filament or marked by a minute depression if absent. Operculum extended downwards and backwards with suboperculum below it; maxillary plate longer than deep; upper profile of head slightly convex; mouth protractile to ¼ length of head." A key for the differentiation of the families Trachypteridæ, Regalecidæ, and Agrostichthyidæ,

formulated by Phillipps (p. 539), has been improved, and extended to cover the family Lophotidæ by Whitley (p. 73), who has also revised the Australian and New Zealand Ribbon-Fishes, of which he admits only four species, namely, *Trachipterus arawatæ* Clarke, *Regalecus pacificus* Haast, *Agrostichthys parkeri* (Benham), and *Regilophotes güntheri* (Johnston).

(c) Comparison of A. parkeri and A. benhami.

A comparison between Benham's type of his *Regalecus parkeri*, as described and figured, and the present specimen reveals the following differences.

In *A. parkeri* the lateral line comes into virtual parallelism with the ventral border of the body at "about 1⅛ in. (28 mm.) behind the head," i.e., a little more than half (0·53) the length of the head (53 mm.) behind the head, and, judging from the figure (pl. ix), about below the 11th ray of the main portion of the dorsal. In *A. benhami* the corresponding point is 40 mm., i.e., rather more than (1·04 times) the length of the head (38·5 mm.) behind the head, and is below the 27th ray.

In *A. parkeri* the greatest depth of body is at the vent. In *A. benhami* it is immediately behind the head, and the depth at the vent is only 80 per cent. of the greatest depth, the falling-off behind the nuchal region being quite striking, even on casual examination. It may be observed that in his diagnosis of the genus Phillipps gives the depth at the vent as being about 93 per cent. of the greatest depth of the body; and speaks of his specimen as being "2½ in. high along the greater part of the anterior portion of the body."

In *A. parkeri* the ventrals are represented by "a pair of minute knobs just behind the level of the pectorals on the throat." If Benham's figure is trustworthy, "just behind the level of the pectorals" is to be interpreted as "just behind the level of the beginning of the base of the pectorals." In *A. benhami* the knobs are wholly behind the base of the pectoral by a distance 1·6 times distance of base of pectoral from ventral border of body.

In *A. parkeri* the crest-like nuchal portion of the dorsal comprises 7 rays; in *A. benhami* apparently only 3.

In *A. parkeri* the pectoral has 10 rays, in *A. benhami*, 8. I can in no way reconcile the large barrel-like lobe, intersecting the lateral line, and surmounted by short terminal rays,

as figured by Benham, with the delicate acuminate pectoral, supported on a small basal lobe, of the present specimen, which, however, is closely approached by that in Phillipps' photograph.

In *A. parkeri* there is "on the palate a small median tooth." In *A. benhami* there are one median and a pair of much smaller lateral vomerine teeth.

In *A. parkeri* the iris has a black border enclosing a vertical oval silver region. In *A. benhami* it appears to be wholly black, speckled with green.

Minor points of difference, as judged from Benham's plate, include: (*a*) distance of eye from maxillary, expressed in terms of distance of eye from dorsal profile of head, is about twice as great in *A. parkeri* as in *A. benhami*; (*b*) posterior border of maxillary, which is shown as being backwardly convex in *A. parkeri*, is backwardly concave in *A. benhami*, in which latter, also, the postero-inferior section of the border is more nearly rectilinear; (*c*) some differences in arrangement of striæ on maxillary and operculum; (*d*) the depression extending forward in front of the upper fourth of eye is narrowly subtriangular in *A. parkeri*, broadly oval in *A. benhami*.

The data relating to Phillipps' specimen are too few and indefinite to permit of a detailed comparison being made between it and the present specimen.

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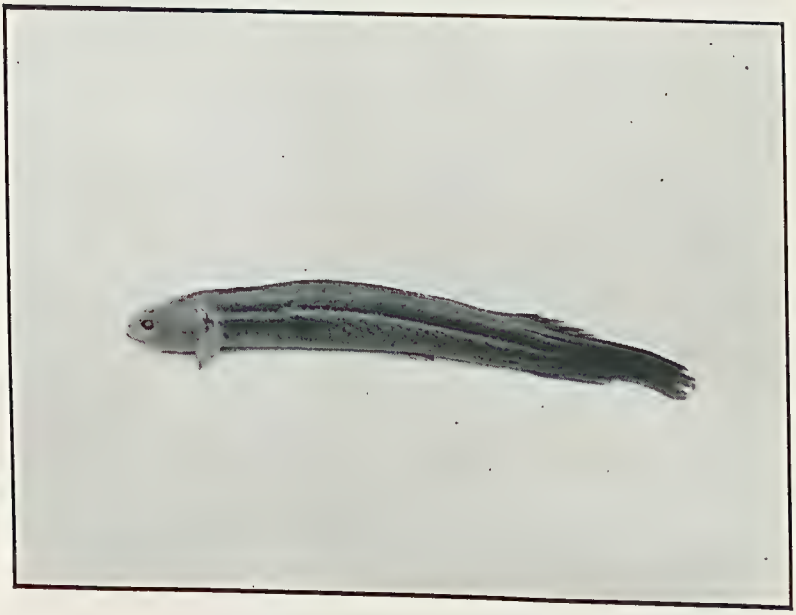

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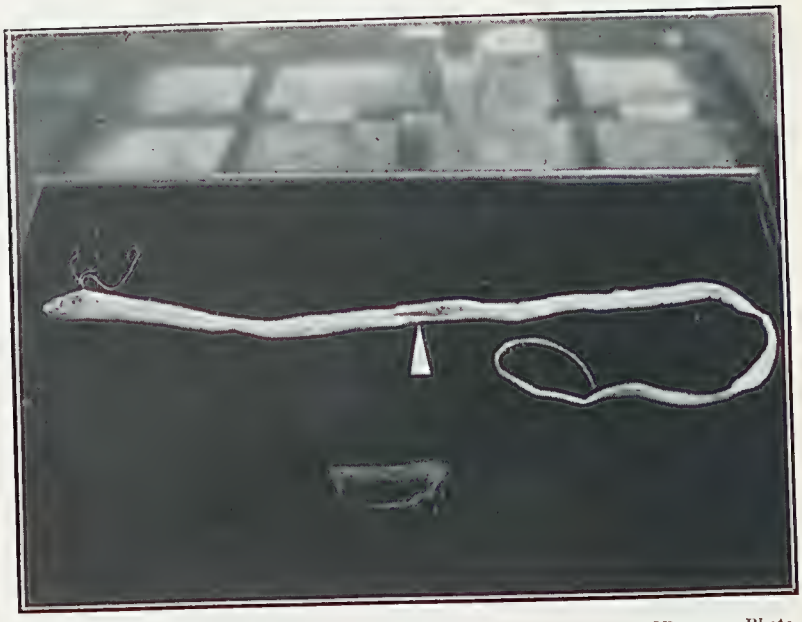

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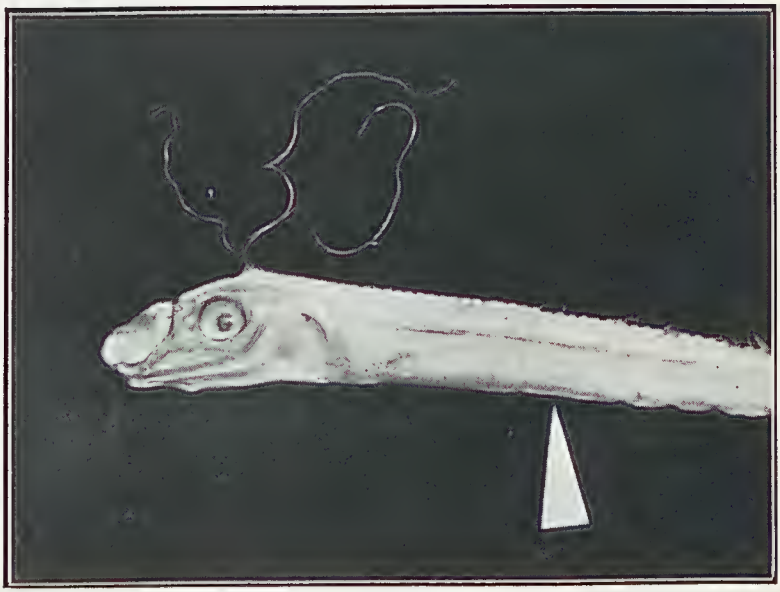

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EXPLANATION OF PLATES.

PLATE VI.—*Galaxias cleaveri*, sp. nov. Holotype. About natural size.

PLATE VII.—*Agrostichthys benhami*, sp. nov. Holotype; total length 811 mm. The arrow-head marks the position of the vent.

PLATE VIII.—*Agrostichthys benhami*, sp. nov. Anterior end of holotype, slightly enlarged. The arrow-head marks the point at which the lateral line comes into virtual parallelism with the ventral margin of the body.

A NOTE ON THE SO-CALLED MINUTE SNAKE OF TASMANIA.

By

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(Read 25th September, 1933.)

There is throughout Tasmania a deeply-rooted belief in the existence in the island of a distinct species of snake, of small size, the "Minute Snake." While it is perhaps usually taken for granted among naturalists that the supposed Minute Snake is simply the young of one of our three duly accredited species, this explanation does not seem to be adequately established by any precise published data, and is, in my experience, almost invariably contested stoutly by bush-dwellers.

The collection of definite evidence on the subject is a matter of surprising difficulty. Time and time again have I been earnestly assured of the specific distinctness of the form in question; but in spite of repeated efforts, encouraged by not a few promises of assistance, it is only during the present year that I have been fortunate enough personally to examine any small snake that has been claimed to be the elusive Minute Snake. In the circumstances, it seems advisable to put on record a note on the result of the examination of two such specimens.

Specimen No. 1.—Received alive at the Museum (Reg. No. 1098) on 30th June, 1933; forwarded by Mr. J. H. White, "Ullapool," Winkleigh, who at my request kindly interested himself in the acquisition of evidence on the matter, and who says of the specimen in a covering letter, "I think it is what we call the Minute Snake." The specimen is a young, but typical, example of *Denisonia coronoides*. Total length, 233 mm.; tail, 43 mm. Dorsal surface olivaceous brown throughout. Ventral surface of head yellowish-grey, spotted with white and dark-brown. Ventral surface of body and tail in general light-orange, tending anteriorly towards yellow, posteriorly towards salmon-pink. Black

streak on side of head, passing through eye, but not continued across rostral; below it, bordering the upper lip, a yellowish-white streak. Scales in 15 rows; longitudinally striated. Ventrals 147, subcaudals (in single row) 55; anal entire. Head-shields fully conformable with specific diagnosis of Boulenger (1896).

Specimen No. 2.—Received alive at the Museum (Reg. No. 1099) on 7th July, 1933; forwarded by Hon. H. A. Nichols, M.L.C., of Ulverstone, who in a covering letter states, "This small but lively snake was caught at Preston recently. I think it is a young whipsnake. Some at Preston think it a new species, called 'minute snake.'" Mr. Nichols' identification is correct; the specimen is a young *Denisonia coronoides*. Total length, 180 mm.; tail, 30 mm. Dorsal surface, viewed with naked eye, dull, slightly olivaceous brown throughout; examination with a lens shows the basal half, or rather more, of each scale bears numerous small isabelline spots. Ventral surface of head dark slate-grey, minutely dotted with whitish. Ventral surface of body and tail yellowish-orange, crossed at bases of scutes by dark-brown transverse bars, best marked anteriorly, obsolescent towards tail. Black streak on side of head, passing through eye, but not continued across rostral; below it, bordering the upper lip, and continued backward along side of body for a distance rather greater than the length of the head, a whitish streak, sparsely speckled with dark-brown. Scales in 15 rows; longitudinally striated. Ventrals 147, subcaudals (in single row) 45; anal entire. Head-shields fully conformable with specific diagnosis of Boulenger (1896).

REFERENCE.

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TASMANIAN AMPHIBIA IN THE MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASSACHUSETTS.

By

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(Read 25th September, 1933.)

INTRODUCTION.

Though there are represented in the collections of the Museum of Comparative Zoology all of the 19 genera and 75 of the 85 valid species, or races, of Australian amphibia, no Tasmanian material has been received until this year. Recently, through the generous co-operation of Mr. E. O. G. Scott and others, we have been able to complete our collection with all the nine species known to be found in Tasmania.

It will be recollected that on various occasions several species normally occurring on the Australian continent have been attributed to Tasmania. Prominent among these are:

Hyla peronii (Tschudi) and

Limnodynastes peronii peronii (Duméril and Bibron)

both of the records resting on a single individual of its species, presented to the British Museum by Sir A. Smith prior to 1858. In view of the fact that no others have been taken during the past three-quarters of a century, and taking into account the numerous instances of Sir A. Smith having inaccurate locality data on his specimens,* it seems reasonable to drop *Hyla peronii* and *Limnodynastes p. peronii* from the Tasmanian list until such time as they may be proved to actually occur upon the island.

Two others, viz., *Hyla krefftii* Günther and *Hyla calliscelis* Peters, have been correctly recorded from Tasmania, but for reasons explained elsewhere I consider both these species synonymous with *Hyla jervisiensis* Duméril and Bibron, a tree frog which is abundant at Launceston.

* Such as *Agama cælaticeps* Smith and *Pholeophilus capensis* Smith, described as from South Africa, though in reality from Australia, being synonyms of *Amphibolurus diemensis* (Gray) and *Riopa lineata* (Gray).

Of the nine species known to occur in Tasmania, only one—*Crinia tasmaniensis* (Günther)—is restricted to the island. It seems probable, however, that the typical forms of *Crinia lævis* (Günther) and *Hyla ewingii* Duméril and Bibron may be found to be similarly confined, their places being taken upon the continent by subspecies. Unfortunately much confusion exists as to the status of some of these mainland races.

I should like to take this opportunity of expressing my indebtedness to Dr. F. N. Blanchard, of the University of Michigan, for lending and donating specimens; to Mr. Clive E. Lord, for putting me in touch with the Queen Victoria Museum; and finally to Mr. E. O. G. Scott, for his exceeding kindness in procuring material through the co-operation of the schools. In the following pages I have given Mr. Scott's name as collector, and though all the material available to me is listed, some of it has been returned, named, to the Queen Victoria Museum. I am also under deep obligation to Mr. Scott for seeing these notes through the press, which was impossible for me to do at this distance.

A Key to Aid in the Identification of Tasmanian Amphibia.

Toes not extensively webbed, their tips not dilated into small disks 1
Toes extensively webbed, their tips dilated to form small disks 6

1. Vomerine teeth in a strongly-developed, transverse series behind the choanæ; belly usually immaculate 2
Vomerine teeth absent or indistinct; belly heavily marbled or mottled 3

2. Inner metatarsal tubercle longer than the free portion of the adjacent inner toe.... *L. d. dorsalis*
Inner metatarsal tubercle much shorter than the free portion of the adjacent inner toe ..... *L. tasmaniensis*

3. Inner toe of the forward-pressed hind limb extends beyond the end of the snout ..... *C. s. signifera*
Inner toe of the forward-pressed hind limb does not extend beyond the end of the snout 4

A Key to Aid in the Identification of Tasmanian Amphibia—*continued.*

4. An inner (sometimes indistinct) but no outer metatarsal tubercle; belly smooth	*C. l. lævis*
An inner and also an outer metatarsal tubercle	5
5. Back and belly smooth; hind aspects of thighs usually uniformly dark, sometimes mottled	*C. tasmaniensis*
Back slightly warty, belly areolate or granular; hinder aspect of thighs distally with a large orange patch	*P. bibronii*
6. Fingers free of web; digital disks extremely small	*H. aurea*
Fingers webbed; digital disks moderately dilated	7
7. Hinder side of thighs red; size smaller	*H. e. ewingii*
Hinder side of thighs yellow; size larger	*H. jervisiensis*

1. Tooth-like ridges on the anterior roof of the mouth.
2. Internal openings of the nostrils on the anterior roof of the mouth.
3. A nodular or ridge-like swelling on the sole close to the base of the inner toe.

Ceratophryidæ.

The South American genus *Ceratophrys* of Boie, 1825, must take precedence over *Leptodactylus* of Fitzinger, 1826, as the type genus for the family called Cystignathidæ by Boulenger in 1882, being based on *Cystignathus* of Wagler, 1830. The genus *Pseudophryne* of Fitzinger, 1843, placed by Boulenger in the Bufonidæ, is now considered one of the Ceratophryidæ.

Limnodynastes dorsalis dorsalis (Gray).

Cystignathus dorsalis Gray, 1841, in Grey's Journ. Exped. West. Australia, p. 446: Western Australia.

♀ (M.C.Z. 19258) Eaglehawk Neck, T. (F. N. Blanchard), 1928.

♂ (M.C.Z. 19330) Tasmania (T. M. S. English), 1901-1903.

♀ (M.C.Z. 19371) Stanley, T. (E. O. G. Scott), 1933.

Trinomials must be used for this species, since Fry (1913, p. 23) defined several "varieties" which are in reality good geographical races. Three of the four races are represented in the Museum of Comparative Zoology. The typical form is distinguished from all the others by its smooth back.

English (1910, p. 629) states that he caught only one of these frogs, but Mr. E. O. G. Scott assures me that there is a second specimen collected by English on exhibition in the Queen Victoria Museum. Our specimens measure: ♂ 58 mm., ♀ 60 mm.

Limnodynastes tasmaniensis Günther.

Limnodynastes tasmaniensis Günther, 1858, Cat. Batr. Sal. Brit. Mus., p. 33, Pl. ii., Fig. B: Tasmania.

1 (M.C.Z. 19333) Launceston, T. (E. O. G. Scott), 1933.

Both Fletcher (1897, p. 662) and English (1910, p. 628) record this species from Launceston, where it is common. I have compared it with examples from Victoria and from Eidsvold, Queensland. Our specimen is immature, measuring 31 mm. from snout to anus.

Crinia signifera signifera (Girard).

Ranidella signifera Girard, 1853, Proc. Acad. Nat. Sci. Philad., 6, pp. 421-422: Australia.

1 (M.C.Z. 19225) Near National Park, T. (F. N. Blanchard, 1928).

1 (M.C.Z. 19334) Launceston, T. (E. O. G. Scott), 1933.

Trinomials are employed, as the Western Australian race, *C. s. ignita* Cope, of which *C. stolata* Cope is a synonym, is distinguished by its larger size and the absence of dark blotches or marbling on the under-surface. *C. s. signifera* of the east and south is smaller, and has these dark marblings, except in *very* young individuals. Through the courtesy of the Director of the Philadelphia Academy and the co-operation of Dr. E. R. Dunn, I have been able to examine the types of *signifera, ignita,* and *stolata.* Our specimen from Launceston is somewhat dried; it measures 18 mm.

Crinia tasmaniensis (Günther).

Pterophrynus tasmaniensis Günther, 1864, Proc. Zool. Soc., London, p. 48, Pl. vii., Fig. 3: Tasmania.

10 (M.C.Z. 19240-9) Cradle Valley, T. (F. N. Blanchard), 1928.

This is the species over which so much printers' ink has needlessly been expended, when, as Blanchard (1929, p. 324) has pointed out, correctly identified specimens from Mt. Wellington and Hobart, collected by Professor E. J. Goddard so long ago as 1909, were in the Australian Museum. Dr. F. N. Blanchard secured good series at Lake Fenton and other localities, his being the first records in the literature since the species was described 64 years earlier. ♂, 17 mm., ♀, 30 mm.

Crinia lævis lævis (Günther).

Pterophrynus lævis Günther, 1864, Proc. Zool. Soc., London, p. 48, Pl. vii., Fig. 4: Tasmania.

6 (M.C.Z. 19226-31) Wilmot, T. (F. N. Blanchard), 1928.

1 (M.C.Z. 19331) Tasmania (T. M. S. English), 1901-1903.

1 (M.C.Z. 19335) Dunorlan, T. (E. O. G. Scott), 1933.

Fletcher (1898, p. 663) later came to regard his *Crinia froggati* as no more than a "variety" of *lævis;* they are undoubtedly very closely related, and it may be that *froggati*, which was described from Buninyong, near Ballarat, Victoria, is the mainland representative of *lævis*. Blanchard (1929, p. 328), however, may be correct in treating *froggati* as a full species. The Dunorlan specimen, taken between March 17 and April 11, is not breeding, whereas the Wilmot series, taken on March 7, are gravid; see also Blanchard (1929, p. 327), who figures the spawn.

Pseudophryne bibronii Steindachner.

Pseudophryne bibronii Steindachner, 1867, Reise Osterr. Freg. Novara. Amphib., p. 34, Pl. v., Figs. 1 and 2: Australia and Tasmania.

4 (M.C.Z. 19336-8) St. Patrick's River, T. (E. O. G. Scott), 1933.

These have been compared with specimens from Sydney, New South Wales, from which they do not appear to be separable. All the examples of both sexes have the ventral marbling extending on to the throat, though the tip of the chin may be free from marbling. In *P. semimarmorata* Lucas, on the other hand, the marbling does not extend on to the throat, which is white in females, dark or dusky in males. The Museum of Comparative Zoology possesses over a hundred examples of *P. semimarmorata* from localities on Mt. Kosciusko, quite close to the type locality in North Gippsland, Victoria. I cannot, therefore, agree with Fletcher (1897, p. 665) in considering these Tasmanian examples of *bibronii* as *semimarmorata*. Of course it is possible, though improbable, that his material from Ulverstone and Launceston does represent *semimarmorata*, for I have seen no examples from these localities. Unfortunately our Tasmanian specimens are somewhat shrivelled, through being placed in too strong alcohol; the largest measures 27 mm. from snout to anus.

Hylidæ.

Hyla ewingii ewingii Duméril and Bibron.

Hyla ewingii Duméril and Bibron, 1841, Erpét. Gén., 8, p. 597: Tasmania.

1 (M.C.Z. 19252) National Park, T. (F. N. Blanchard), 1928.

7 (M.C.Z. 19358-62) St. Patrick's River, T. (E. O. G. Scott), 1933.

14 (M.C.Z. 19363-9) Dunorlan, T. (E. O. G. Scott), 1933.

The outer finger usually with the merest rudiment of web, at most only a quarter webbed; outer toe webbed to base of disk or a little short of the disk; median digital disks as large as, or slightly smaller than, the tympanum; the tibio-tarsal articulation of the adpressed hind limb marks the orbit or (more usually) just beyond; skin of back smooth (in formalin) or with very small, pimple-like warts (in alcohol). Above, grey, forehead to interorbital region lighter, a more or less well-defined silvery streak from the upper lip to the base of the forearm; a broad brown dorsal streak from the interorbital region to above the anus; hinder side of thighs *uniformly red* (in fresh material), or with a few large spots and streaks on a red ground.

The largest ♂ measures 32 mm.; the largest ♀, 37 mm.

Hyla jervisiensis Duméril and Bibron.

Hyla jervisiensis Duméril and Bibron, 1841, Erpét. Gén., 8, p. 580: Jervis Bay, New South Wales.

Hyla krefftii Günther, 1863, Ann. Mag. Nat. Hist. (3), 11, p. 28, Pl. iv., Fig. C: Sydney, New South Wales.

Hyla calliscelis Peters, 1874, Monatsb. Akad. Wiss. Berlin, p. 620: Adelaide, South Australia.

1 (M.C.Z. 19054) Launceston, T. (Australian Mus.), 1933.

63 (M.C.Z. 19339-50) Launceston, T. (E. O. G. Scott), 1933.

3 (M.C.Z. 19351-2) Stanley, T. (E. O. G. Scott), 1933.

6 (M.C.Z. 19353-7) Franklin, T. (E. O. G. Scott), 1933.

Boulenger (1882, p. 383), lacking material of *jervisiensis* as he thought, believed it to be related to *cærulea*. I have good evidence for believing *krefftii* to be a synonym of *jervisiensis*; detailed reasons for this opinion will be given elsewhere (in MS.). On the other hand, Boulenger (1882, p. 407) made *calliscelis* a race of *ewingii*, though he lacked topotypic material of *calliscelis*; his two frogs from King George's Sound, South-Western Australia, may, or may not, have represented *calliscelis*. After comparing a South Australian *calliscelis* with New South Wales *jervisiensis*, I find that they differ in just those characters cited by Fry (1915, p. 84):

"Groin and hinder thigh with accentuated purple blotches ... ... *calliscelis*.

Groin and thigh yellowish with faint brown speckles ... ... *krefftii*."

The large series from Launceston and Franklin, however, show both types and every intergradation between them; on the supposition that large series of South Australian or New South Wales specimens would show similar variation, I relegate *calliscelis* to the synonymy of *jervisiensis*, not deeming it worthy of subspecific rank.

This explains why both *krefftii* and *calliscelis* have, in the past, been recorded from Tasmania by various workers.

Unfortunately Fletcher (1897, p. 665) confused several forms, including *calliscelis*, with *ewingii*. In the latter respect he was followed by English (1910, p. 632). Fry (1915, p. 79) cleared away some of the tangle by naming *H. ewingii alpina* from Mt. Kosciusko, New South Wales. Fletcher had called this mountain form *calliscelis*, for it shares with that form the distinction of possessing purple blotches (brown in *calliscelis*?) on a yellow hinder thigh.

Fry, however, thought that the best solution was to retain *calliscelis* as a race of *ewingii*, and make *krefftii* also a race of *ewingii*; actually he called them varieties. On grounds of geographical distribution they cannot be regarded as races, so I treat *jervisiensis* as a full species, while entirely agreeing that it is closely related to the members of the *ewingii* group.

After careful study of this Tasmanian material I have come to the conclusion that the only safe characters available to distinguish the two species occurring in Tasmania are those which I have employed in the preceding key. There are other average differences of webbing, limb-length, &c., which are of assistance when comparative material is available, but they do not serve to make a sharp and distinct separation between *jervisiensis* and *ewingii*.

The largest ♂ measures 38 mm.; the largest ♀, 45 mm.

Hyla aurea (Lesson).

Rana aurea Lesson, 1830, Voy. Coquille, 2, p. 60, Pl. vii., Fig. 2: Macquarie and Bathurst Rivers, New South Wales.

Hyla aurea var. *cyclorhynchus* Boulenger, 1882, Cat. Batr. Sal. Brit. Mus., p. 411: West Australia.

♂ (M.C.Z. 19332) Tasmania (T. M. S. English), 1901-1903.

♀ (M.C.Z. 19370) Stanley, T. (E. O. G. Scott), 1933.

Binomials only are used, as our extensive Western Australian material of this species shows considerable variation and little grounds for supposing that *cyclorhynchus* should be recognised as a western race. Boulenger's types may represent extremes of variation or a full species.

Our Tasmanian representatives of the Golden Frog measure: ♂, 50 mm.; ♀, 73 mm.—but are surpassed by continental examples.

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TASMANIAN CYCADOPHYTA.

[Part 2.]

By

H. H. Scott,

Curator of the Queen Victoria Museum, Launceston.

(Read 11th December, 1933.)

In a former paper, read before the Royal Society on 12th May, 1930, I gave some illustrated notes respecting certain cycad stems recovered from the Miocene strata at Evandale. The status of these specimens was called in question by certain palæobotanists, both in and outside the Australian Commonwealth. By a fortunate discovery a small piece of a trunk was afterwards found that proved beyond all question that they had an organic origin, and were not, as objected, inorganic concretions. This discovery, however, did not extend the microscopical evidence to the concentric woody layers, but related to the inthrusts of periderm into the central cavity of the stem, a state of things already found to obtain in cycad trunks from Dakota, U.S.A. In September last a splendid section of a trunk was found in the railway ballast-pit, and through the kindness of Mr. G. Curtis, of the Railway Department, and the keen interest manifested in it by the actual finder—Mr. L. V. Mason—we were enabled to secure this unique specimen. Some 2 feet of the trunk, in three fragments, eventually came to hand, and in many places the structure of the woody rings can be readily studied. As the diameter of the bole is 6 inches by 5 inches, we are evidently in possession of the remains of a fully-grown tree. The finding of this stem sets at rest for ever all objections raised against the organic origin of the specimens, and at the same time supplies us with several connecting links that serve to complete our chain of evidence, as will now be shown.

As the 50 lb. weight of fragments obtained at Evandale suggested both *Cycadites* and *Bennettites*, they were exhibited in the Museum cases as being such—all that manifested concentric layers of wood being relegated to the former taxonomy, and those that showed the entire centre to be

altered parenchyma, without woody structure, to the latter. By far the best stems belonged to *Cycadites*, and in exhibition only one perfect illustration of *Bennettites* was shown (Q. V. M. Pal.-Bot. No. 33), but later on a stem was found at Mulgrave-crescent, Launceston, in which woody periderm ran into the central parenchyma in the form of a latticework. Until the recovery, from the Launceston Miocene strata, of this large woody cycad trunk this specimen (Q. V. M. Pal.-Bot. No. 77) was the only evidence available respecting the inthrusting of woody periderm into the central parenchyma. Now, however, the railway ballast-pit section (Q. V. M. Pal.-Bot. No. 66) shows this most perfectly in its lower parts, while the upper areas are completely hollow. Obviously, therefore, this is to be regarded as a growth note, in which the central parenchyma was reinforced at the base of the stem, but the process became unnecessary higher up.

A "developed" section of one of the original specimens that came to hand from Evandale (Q. V. M. Pal.-Bot. No. 31) shows the leaf traces leaving the stem to perfection. The outer surface is heavily scored with the leaf scars, and the fractured surface shows the course of no less than 12 most perfect bundles of leaf traces.

A specimen (Q. V. M. Pal.-Bot. No. 35) has yielded evidence of seeds *in situ* in the strobilus, but so far these are the only ones detected.

Among microscopical details obtained from the railway ballot-pit stem the following were noted:—

(1) Medullary rays.
(2) Bordered pits to tracheids.
(3) Raphides (cubical rather than needle-shaped).
(4) Good evidence as to the resin ducts.

As this is a mere recapitulation of Museum specimens, very little need be said as to the works of palæobotanical authors, except to again refer to Dr. Marie C. Stopes' (D.Sc., Ph.D.) fine work upon the cretaceous flora, in the British Museum Catalogue series, and the valuable books upon fossil botany by D. H. Scott.

A CORRELATION OF THE TASMANIAN PLEISTOCENE GLACIAL EPOCHS AND DEPOSITS.

By

A. N. Lewis, M.C., LL.D., M.H.A.

(Read 11th December, 1933.)

1. Present Progress of Investigation.

During the past year Sir Edgeworth David did me the honour of asking me to contribute a section to his "Geology of Australia," dealing with the Pleistocene glaciation in Tasmania. In the course of this work I found it highly desirable to affix names to the three glacial phases, the existence of which is now fully established. In the space available in Sir Edgeworth's work, I could do no more than use these names. A purpose of this paper is to record my reasons for the choice.

The widespread range of Pleistocene glacial drifts in Tasmania was recognised by Charles Gould as early as 1860, and by 1885 R. M. Johnston had recorded their existence over the whole of the western highlands (Johnston, 1893). Until 1893 no suggestion had been made that there had been more than one glacial phase in Tasmania, but in the paper last referred to R. M. Johnston recorded difficulties in the interpretation of the field evidence, which have since been used to prove the existence of such separate phases (see *loc. cit.*, p. 100). In this branch of learning, however, I must award the palm for early accurate observation and clear geographical discernment to T. B. Moore. As early as 1895 this outstanding explorer advanced a theory that there had been two glacial epochs during the period under review, and advanced evidence which my later investigations confirm entirely (Moore (1895), p. 76; and see also R.S. of Tas., 1893 and 1894, *sub. nom.* T. B. Moore).

Unfortunately, T. B. Moore's theory was disregarded, and for 25 years various writers on this topic floundered in a maze of their own making. By disregarding the very clear evidence of separate and distinct glaciations, they endeavoured to reconstruct the traces of all into the framework of one ice invasion. The result was contradictions everywhere

and observers contented themselves with recording evidence—the reconstruction of ice movements being fraught with so many apparent difficulties. This fact must be borne in mind when studying the numerous reports of glacial phenomena published prior to 1920.

In 1921 Professor Griffiths Taylor drew attention to the clear evidence of a double glaciation in the National Park (Taylor, 1921), although he missed the true significance of the field evidence he recorded, as had I, in my description of the area published in the same volume. Some time prior to 1922 Dr. Loftus Hills had made certain observations in the vicinity of Strahan. These he showed to Sir Edgeworth David, who confirmed Dr. Hills' theory that here was distinct evidence of at least two glaciations (David, 1926). Dr. Hills made some mention of this to me at the time, but he did not publish or, as far as I know, elaborate his ideas then.*

In 1922 (December) I was descending the slopes of Mt. Anne, and, looking over the Huon valley—whether the evening light or the peculiar configuration of the Frankland Range emphasised the fact I know not—but I was struck with the absolute clearness, in the panorama there unfolded, of the evidence of two distinct and superimposed glaciations, the one responsible for the topography of the Huon Plains, the other disclosed in the tributary valleys leading down from the encircling ranges. The fact of a smaller series of valley glaciers, terminating in piedmont moraines, each resting on the older glaciated surface of the wide Huon valley, was too apparent to be missed. With this clear disclosure in the field, I found the key to the task of reconstructing the history of the Pleistocene glaciation in this island. I made reference to this idea in 1923, and definitely advanced the evidence on which I based the conclusion that Tasmania had experienced three Pleistocene glacial epochs (Lewis, 1923, p. 32). I then attempted to correlate the Tasmanian glaciations with those of the Northern Hemisphere, an attempt I have now abandoned. In the same year Sir Edgeworth David, after full consultation with all Tasmanian geologists, set his seal to the classification of the Pleistocene glaciations into three easily distinguishable phases (David, 1923).

After further study, the position was crystallised by the Report of the Glacial Sub-Committee of the A.A.A.S.,

* The distinctions noticed by Moore, Hills, and David were between the Malanna and the Yolande glaciations; those noticed by Taylor were between the Yolande and Margaret glaciations.

Adelaide meeting, 1924, in which I elaborated my previous ideas, and Sir Edgeworth David followed with modifications and confirmation of the general theory. (Lewis, 1926; David, 1926.) Since 1926 little further advance has been made, except in the direction of the collection of further evidence, all of which confirms the conclusions enunciated in the report referred to lastly above.

2. Nomenclature Assigned to the Subdivisions of the Pleistocene Glaciation.

For reasons to be set out hereafter, I have had to reject an absolute correlation between Tasmanian and European glacial epochs. The desirability of local names in cases in which absolute correlation is not absolutely certain is recognised. It is most difficult to fix upon any Tasmanian locality as absolutely typical of any of the glacial phases, as the features of all are so uniform throughout the country. After examining the claims of every recorded area to the title of type locality, I decided that the district in which clear examples of each phase could be found in the smallest compass was that described by Sir Edgeworth David. This area possesses the advantages for such purpose of accessibility and compactness, and has already been thoroughly mapped. Further, it has been described by the greatest authority on the subject, and Tasmania may well pay Sir Edgeworth David the compliment of choosing the area he has described as the type locality for its glacial geography.

For these reasons I selected the following names for the three identified glacial epochs:—

1. Malanna Glaciation: For the earliest, most extensive ice-cap stage of the Pleistocene period.
2. Yolande Glaciation: For the second, cirque cutting and most obvious stage.
3. Margaret Glaciation: For the most recent, or mountain-tarn, stage.

The applicability of this terminology will be appreciated on reference to Sir Edgeworth's description of the area. Nowhere else are the three phases to be seen in such clear juxtaposition within an area of the same size and accessibility.

3. The Late Tertiary and Pleistocene Succession in Tasmania.

The continual sub-aerial conditions, the confusing succession of land movements, and the absence of definite time marks render our period difficult to correlate with the accepted subdivisions of geological time. Indeed, as far as the geology of Tasmania goes, there is no justification for separating Pliocene, Pleistocene, and Recent periods.

At one end there comes the marine limestone of Table Cape and the Tamar basin, probably of Miocene age, with the freshwater leaf beds of the Launceston and Derwent basins, not far removed in point of age. Overlying these is the older olivine basalt, which may be of Miocene or Pliocene age. From the date of the latter rock, itself most uncertain, all is doubtful at present. The succession of the three glacial periods is clear as between themselves, but all search has failed to disclose a starting point for correlating them with the basalts and older tertiary formations, on the one hand, and the raised beach and river terrace deposits of Northern and Eastern Tasmania, which are usually referable to Recent age, on the other hand.

In point of fact, and it is one of my present purposes to stress, the glacial epochs cannot be segregated into a division by themselves and referred to " Pleistocene " age, and the raised beach and terrestrial deposits cannot be separated into another compartment and called " Recent," as has been done heretofore. The two series were probably deposited contemporaneously, but in different parts of the country.

As far as my observations have extended, no clearly defined Malanna glacial deposit or erosion feature stands in juxtaposition to defined tertiary strata or older basalt. We merely presume that the latter are older than any late Tertiary glaciation. This is supported by the balance of probabilities, but by nothing more. The relationship between the older and the newer basalts has not been worked out to such a degree that we can distinguish a given occurrence with certainty. It appears that a very considerable interval of time elapsed between the two eruptions, probably a greater interval than exists between the eruption of the newer basalt and the present day. I was struck by the fact that in the Coal River valley, immediately north of Richmond, newer basalts overlie clays and soils in no way distinguishable from those cultivated to-day in the immediate vicinity.

On the Central Plateau glacial features are superimposed on the newer basalts. But here we observe the faint feather-edge of the glaciation, and it is difficult to distinguish its period with certainty. There is no difficulty in saying that the Yolande glaciation was more recent by a considerable space of time than the eruption of the newer basalts. If my interpretation of the field evidence is correct, the Malanna glaciation is also superimposed over sheets of newer basalts in the vicinity of the Great Lake and elsewhere. But I have not yet established this fact to my complete satisfaction. Nevertheless, the balance of probabilities again points to the fact that the newer basalts preceded the Malanna ice-cap.

Of the boundary, in Tasmania, between the Pliocene and the Pleistocene, or the correlation of the Malanna glacial epoch to this point of time, we know nothing at present. The Wynyard stage, the older basalts, the river drifts and lacustrine deposits, and the newer basalts are distinct in themselves (see Nye and Lewis, 1928, for fuller descriptions), and no doubt exists as to the local succession. But they present a very broken and uncertain record of Tertiary times, and provide no connection with subsequent events.

In these circumstances we cannot date the Malanna ice age. We may accept the general correlation of the Tasmanian ice age with the Pleistocene period. It certainly is far later than the Miocene. Since that period the older basalts were erupted and eroded, great depths of terrestrial deposits accumulated and also eroded, and river systems were invaded by newer basalts at a considerably more recent date. From approximately the date of these flows until relatively modern times Tasmania has been subject, at least in higher altitudes, to more or less glacial conditions. But our real problem is: did our southern phases correspond with those of the Northern Hemisphere, or did they occur alternatively with the glacial and inter-glacial epochs in the Northern Hemisphere, or were they merely approximately contemporaneous without any real inter-connection? The solution of this problem would be Tasmania's greatest contribution to the knowledge of recent glacial phenomena. Unfortunately, an answer is not yet to hand.

It is clear that the Malanna glaciation was the most intense, and it is safe to state that it covered from a third to a half of Tasmania. The many apparent breaks and inconsistencies are due to post-Malanna erosion. It is also clear that the time-interval between the maximum phase of

the Malanna glaciation and that of the Yolande glaciation was far greater—I would say four times greater—than the time-interval between the Yolande glaciation and the present day. The remains of the Malanna glaciation have been largely eroded by the river systems; elsewhere the limits have been submerged under the sea, and the origins have been obliterated by the Yolande glaciation. It is therefore only in a few favoured localities that such evidence persists. It is no wonder that early observers connected these vestiges with the neighbouring Yolande valley glaciers rather than with the distant occurrences, now separated by miles of waterworn valley.

As to the duration of the Malanna glaciation, I can only say that from its extent and remains it appears to have been of far longer duration than the Yolande period. Then came the Malanna-Yolande inter-glacial. This also lasted for a very lengthy period. The Yolande glaciation occurred upon, virtually, our present day physiography; the Malanna glaciation left a physiography which differed so materially from that which we know that it is difficult to reconstruct it. Vast changes occurred during the Malanna-Yolande inter-glacial, and, moreover, obviously required a vast space of time to impart the results which are apparent. The date of the land movements that elevated most of our central plateaux is disputed. I incline to the idea that several sectional uplifts occurred, and that the first, involving the country from the west coast to a line from the Forth River to New River, occurred immediately prior to the Malanna glaciation, and the succeeding uplifts to the east occurred during the Malanna-Yolande inter-glacial. But I do not wish to press this view, as it is not accepted by the Geological Survey.

Nevertheless, this is certain: many rivers—the Pieman, King, Gordon, Huon, Derwent, Ouse, Lake, Mersey, and Forth, to name only the more important—cut gorges from 1000 to 2000 feet deep in the hardest of rocks during the Malanna-Yolande inter-glacial. This is the explanation of the fact that there are widespread Malanna morainal deposits at Strahan and south of Macquarie Harbour, but none in the lower King and Gordon Rivers, down which the ice would naturally flow; and similarly with other rivers. The erosion during the Yolande-Margaret inter-glacial has been inconsiderable, and, making all allowances for the increase in erosion in the lower reaches of rivers fed by Yolande

glaciers, it appears, from the extent of the Malanna-Yolande inter-glacial erosion, that the duration of this inter-glacial period, in itself far exceeded the time from the Yolande glaciation to the present day. Indeed, if the commencement of the Malanna glaciation were to be dated as a million years ago, I would estimate the length of the Malanna-Yolande inter-glacial as 600,000 years, and date the commencement of the Yolande glaciation not earlier than 100,000 years ago. This period would then have lasted for 50,000 years, with an inter-glacial period of about half as long, and the Margaret glaciation commencing about 20,000 years ago and lasting until within 5000 years or less of the present day. I place no reliance on these dates as such, but the relative time-interval represents my view of the proportion of the Pleistocene period occupied by each phase. The Yolande glaciation followed. This is unmistakable. It has been responsible for the moulding of the topography of the altitudes over 2000 feet—and this area is very considerable. It has also been responsible for the more obvious moraines and glacial deposits. It cannot be stated with absolute certainty that there was an absolute inter-glacial period between the Yolande and the Margaret glaciations, but all the evidence points to such occurrence. Certainly the Margaret glaciation was a definite and distinct feature, too universal, persistent, and protracted to be regarded as merely a phase of the recession of the Yolande glaciers. It probably represented a definite onset and waning of glacial conditions, but to a less degree of intensity, both as to level affected and time occupied, than the Yolande glaciation. This phase persisted until very recently. Indeed, it has not yet entirely departed, although permanent ice no longer exists.

Contemporaneously with the ice periods on the highlands and west coast, considerable river and estuarine deposits were accumulated in the lowlands and along the north and east coasts, and raised beaches of indefinite age appeared. Great differences in the flow of the principal rivers and consequent eroding power, due to marked changes of climate, are also apparent. All these are attributable to the same causes as produced the ice-flows further west. It is most apparent that our rivers and creeks have all shrunk in volume in the near past. This is natural considering that most were ice-fed during earlier periods. No attempt has yet been made to correlate the river terraces and raised beaches with the several glaciations, but this should not be impossible. I have to content myself here with stressing

that these deposits, which so largely cover the later basalts through Southern, Eastern, and Northern Tasmania, and fringe these coasts, are largely the results of the glaciation of the elevated country inland, and cannot be separated from the Pleistocene glacial periods. Similarly, it is impossible to differentiate downwards between Pleistocene and Recent strata. "Post-Margaret deposits" appears to be the more accurate term for those which can be differentiated as such.

4. Correlation With the Northern Hemisphere.

I have described three glacial periods as occurring in Tasmania. These three are distinct, and their occurrences are distinguishable. The general time-relationship, considering Tasmania alone, has been established. My investigations, however, do not preclude the occurrences of other glaciations. Three possibilities exist:—

(i) A pre-Malanna glaciation, the traces of which have been obliterated by erosion or by the more intense Malanna glaciation.

(ii) A phase between the Malanna and the Yolande, the evidence of which has been confused with one or other of the identified glaciations or obliterated by the Yolande glaciers.

(iii) A subdivision of the Malanna glaciation into more than one phase.

I am satisfied that the typical Yolande glaciation cannot be subdivided, and that none occurred between the typical Yolande and the Margaret or after the Margaret phases. As to the other possibilities mentioned above, all I can say is that no evidence exists. But in view of the present state of our knowledge, and the very fragmentary remains of the Malanna glaciation, this does not exclude such possibilities. The point is important. If we have had three glaciations, there would be a temptation to fit them in to the interglacial periods of the Northern Hemisphere. If we have had contemporaneous glaciations with the Northern Hemisphere, we must explain the absence of evidence of the missing one. If it is the earliest that is missing, as I strongly believe, and the Malanna glaciations can be correlated with the Mindel, it is possible that Tasmania escaped the Gunz glaciation owing to the fact that our mountains had not at that time been uplifted to the necessary height. To establish this fact would be to discover a date for the final elevation of our

horst plateaux. In any case, I feel that a close study of the earlier phases of the glacial period, and the relationship of river erosion and deposition thereto, will disclose that there also exists a powerful earth-movement factor. It is a purpose of this paper to point out that none of these factors can be understood separately.

In the present state of our knowledge it is impossible to correlate the Tasmanian glacial periods with those of the Northern Hemisphere. It is tempting to connect the Malanna glaciation with the Mindel, the Yolande with the Riss, and the Margaret with the Würm. In my opinion, however, such can be no more than a guess, and may lead to fatal error. For the present, we can only adhere to local terminology and correlation.

5. Future Investigations.

This field is really so lightly touched in essentials that any detailed investigation of the various problems mentioned above would be welcomed. It seems that the Yolande glaciation is our one definite time-mark, and that the work of correlation, both local and world-wide, must start from this base. Thence, the search for a Yolande moraine superimposed on a Malanna moraine must be prosecuted to success. A careful investigation of the edges of the Malanna deposits at Strahan may give a clue as to the succession downwards. It appears at present as if the river terraces or raised beaches of Pleistocene age are nowhere closely associated with glacial deposits, but an investigation of the shore-line between Recherche and Temma should throw sufficient light on this succession to establish a basis for inter-correlation. Failing any such discovery, a close study of the succession of river terraces and their erosion should provide a sequence which can be reasonably correlated with the glacial phases. I am satisfied that the data exist, but up to the present I have not been able to identify a reliable starting-point.

I conclude by expressing the hope that workers interested in Tasmanian glaciation will advance from a mere description of deposits and erosion forms to a logical correlation of the features observed, either to confirm or to contradict the conclusions summarised above.

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A CONTRIBUTION TO THE STUDY OF TASMANIAN COPEOGNATHA.

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Six Text Figures.

(Read 11th December, 1933.)

Probably few Tasmanian insects have been so generally neglected by students as those usually small but plentiful forms which comprise the order Copeognatha or Psocoptera. The Australian and New Zealand species have been studied by MacLachlan, Enderlein, and Tillyard, but the literature contains only isolated references to Tasmanian forms.

Among the species dealt with in the present paper are two archaic forms of more than ordinary interest. One of them closely resembles *Sphæropsocus künowi* Hagen, a fossil species found in Baltic amber, whilst the other is a member of the rare and primitive family, Lepidopsocidæ.

Suborder PARAPSOCIDA Tillyard, 1926.

Family Lepidopsocidæ.

Genus *Tasmanopsocus* n.g.

Diagnosis.—Head very hairy. Thorax, abdomen, and legs clothed with both scales and hairs. Three ocelli present. Antennæ with 40 joints. Apical joint of maxillary palpi hatchet-shaped. Tibial segments of the legs armed with long powerful spines, as in the genus *Echinopsocus* Enderlein. Tarsi three-jointed. Forewings bluntly pointed and short, reaching only to the middle of the abdomen. The venation is not constant, but the arrangement of the veins as shown in Fig. 2 B holds good in most specimens of the genotype. Sc is not fused with R. The radial sector (Rs), which is unbranched, leaves R near the middle. M is fused with Cu_1 towards the base. Both M and Cu_1 are branched dichotomously. Cu_2 is absent. In the wings of some specimens 1A fades out towards the base. In other cases it is well developed and occasionally branched. As in the genus *Echmepteryx* Aaron, there is no distinct pterostigma. The

wings are clothed with hairs, coarse bristles, and striated, cultriform scales. The coarse bristles are minutely barbed. They occur along the veins and in the costal, anal, and apical regions of the wing. Each bristle rises from a cup-like socket. (Fig. 2 H).

The hindwings are minute, membranous, scale-like vestiges not extending beyond the metathorax.

Genotype.—Tasmanopsocus litoralis n.s.

Habitat.—Southern Tasmania.

Tasmanopsocus litoralis n.s.

Female.—Length of body, 2·9 mm.; length of forewings, 1·2 mm.; length of antennæ, 2·4 mm.

Colour.—Body light-brown, with a silky sheen, due to the presence of scales. Epicranium and frons marked with a dark-brown pattern, as shown in Fig. 2 A. Clypeus, clypeolus, labrum, and genæ dark-brown, almost black. Distal joint of maxillary palpi dark-brown, other joints light-brown. Antennæ light-brown. Femora dark-brown. Tibiæ light-brown, encircled with two broad dark-brown rings (Fig. 1 A). Tarsi light-brown, becoming darker towards the base. Abdomen light-brown, with a darker median longitudinal band on the dorsal side.

Head large and triangular. Surface very hairy. Paired eyes, finely pubescent, 0·34 mm. in diameter, composed of numerous ommatidia, and occupying the posterior angles of the head. Epicranial and frontal sutures well marked. Three small ocelli present and somewhat widely spaced. Antennæ long and slender, consisting of 40 segments, which are subequal in length. From the third outwards the segments possess minute hairs, arranged in a series of rings, and a whorl of four long slender spines. (Fig. 1 E). Maxillary palpi, four-jointed. The apical joint is hatchet-shaped, slightly longer than the second joint, and provided with a number of sensory pits. The second joint has a small dentiform spine on the inner side near the base (Fig. 2 A). All the joints are clothed with fine hair. Styliform appendages tridentate (Fig. 1 B). Mandibles as shown in Fig. 1 D.

Thorax.—Prothorax moderately large and visible from above. Protergum with a transverse fringe of coarse erect hairs, which form tufts at the sides. Mesothorax separated from metathorax, and much larger than either pro-

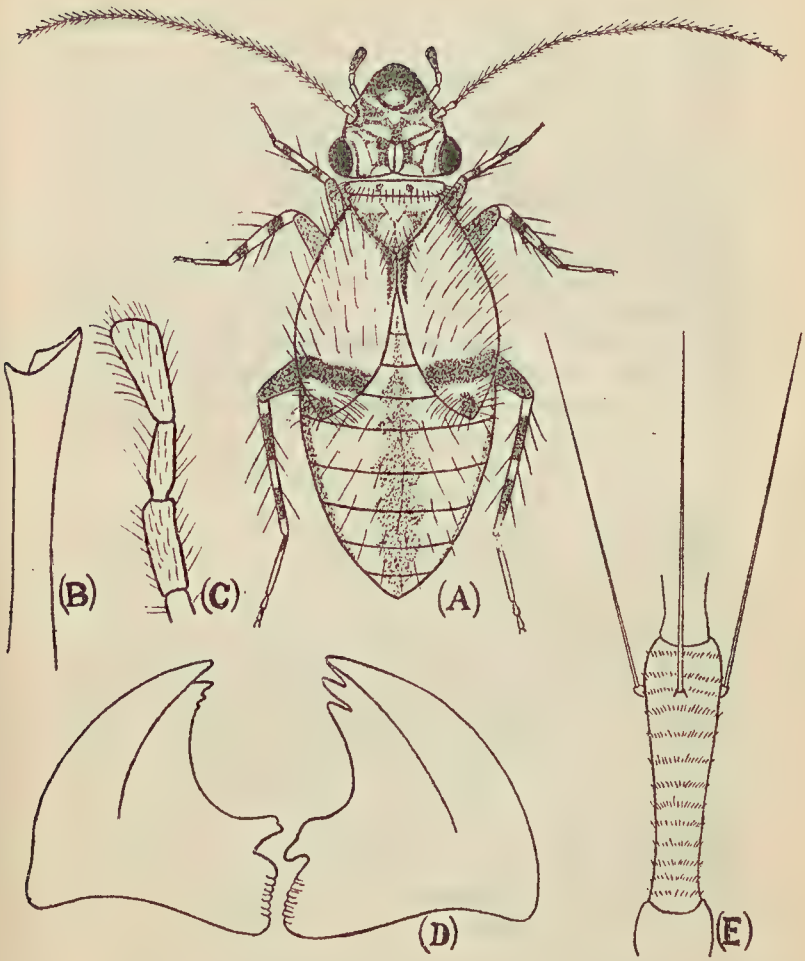

Fig. 1. *Tasmanopsocus litoralis* n.s.—(A) Dorsal view of insect without the scales. (B) Styliform appendage. (C) Maxillary palpus. (D) Mandibles. (E) Joint from antennæ.

thorax or metathorax. It is covered with scales between the forewings. Legs clothed with long hairs and elongate, leaf-like, striated scales (Fig. 2 D). Tibiæ armed with long powerful spines, as in *Echinopsocus erinaceus* Enderlein (p. 331, 1903). Tarsi three-jointed, the basal joint being longer than the other two joints combined. The apical joint is slightly curved dorso-ventrally. The apical and middle joints finely pubescent; the basal joint with a row of six short spines on the outer side (Fig. 2 G). The tarsal claws are long and almost straight, with a single small tooth before the apex (Fig. 2 G). At the base of the claws is a serrated structure resembling that which Enderlein calls a "Gleitsole" in the case of *Copostigma indicum* Enderlein (p. 232, 1903). The leg segments have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I.	0·61	0·56	0·23	0·05	0·08
Leg II.	0·61	0·64	0·27	0·07	0·08
Leg III.	0·75	1·00	0·41	0·08	0·08

Wings.—Forewings bluntly pointed and reaching to the fifth abdominal segment. Dorsal surface of the wing is covered with cultriform striated scales measuring 0·087 mm. long (Fig. 2 E). Each scale has about 19 striæ. Coarse bristles, which are finely barbed, occur along the veins and on the costal, anal, and apical regions of the wing. One bristle measured 0·18 mm. long. The anal margin and the tip of the wing are marked with black, whilst a broad black transverse bar crosses the wing in the apical third (Fig. 1 A). Venation is described in the diagnosis of the genus given above. Hindwings are minute vestiges of 0·11 mm. long.

Abdomen clothed with scales and long dark hairs. Most of the scales are tridentate and marked with 18 or 19 distinct striæ (Fig. 2 C). One of these scales measured 0·066 mm. long. The distal half of the scale is dark-brown, the base light-brown. Some of the abdominal scales are leaf-like, resembling those on the legs.

Habitat.—Opossum Bay, near South Arm, 22nd August, 1933. The Domain, Hobart, 23rd September, 1933.

The specimens found at Opossum Bay were taken on the underside of stones, among the dry rubbish which collects above high-tide mark. This rubbish seemed to consist chiefly of the dead branchlets of sheoaks (*Casuarina quadrivalvis*, Lab.) growing near the shore. Specimens collected on the Domain, Hobart, were also found under stones in the vicinity of sheoaks.

When disturbed *Tasmanopsocus litoralis* runs with surprising speed. It does not live in colonies, nor does it spin a web. Specimens collected on 22nd August were placed in tubes with some of the dry debris amongst which the insects were found. On the 24th August three eggs were laid in one of the tubes. The eggs were not deposited in a mass, but laid singly, and attached to dry grass-stalks, pebbles, &c. One of the eggs measured 0·66 x 0·30 mm., and had the form shown in Fig. 2 F. The chorion is ornamented with longitudinal ridges and a hexagonal pattern. On the dorsal surface is a sagittal flange, which opens longitudinally when the egg hatches. Covering the outer surface of the chorion is a delicate semi-transparent white membrane, which is perhaps merely the solidified secretion used for attaching the egg at the time of laying. However, it is easily separated from the chorion. When laid the egg is white, and remains white for seven days. The chorion then becomes brownish-purple. This colour-change shows faintly through the outer membrane, giving the egg a purple tint.

On the 19th September two eggs were found to have hatched. The first larval instar measures 0·64 mm. long, and already shows the head markings of the adult. It possesses no wings. The body is devoid of scales, but is lightly clothed with long brown bristles. The antennæ are nine-jointed, and the joints are furnished with a whorl of long bristles, as in the imago.

Type.—Holotype in Australian Museum, Sydney.

Family Atropidæ.

Genus *Atropos* Leach.

Atropos pulsatoria (Linn.).

This introduced species is common in houses in Tasmania and in many other parts of the world.

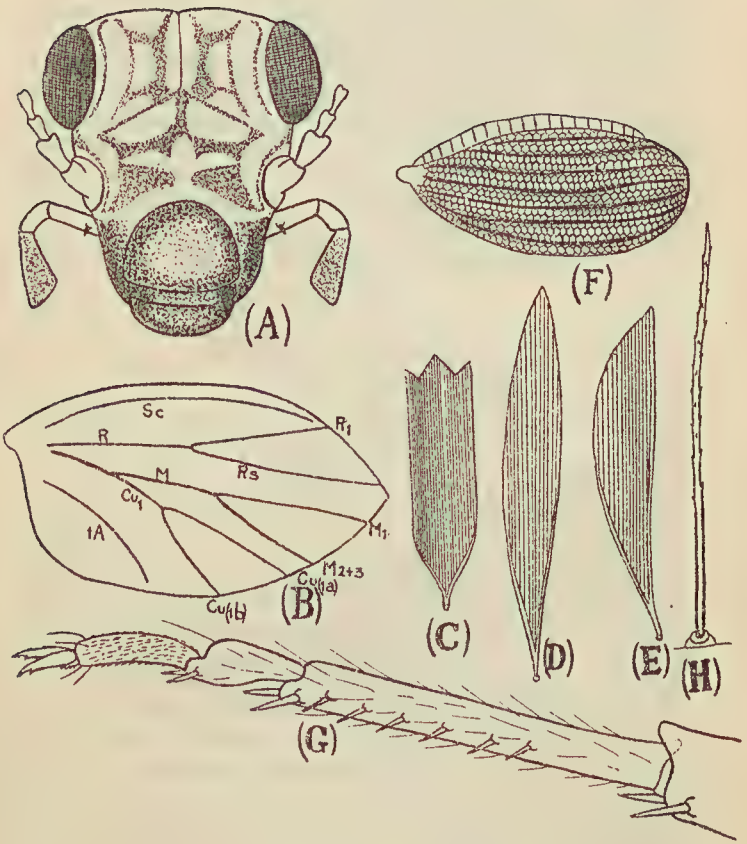

Fig. 2. *Tasmanopsocus litoralis* n.s.—(A) Front view of head. (B) Forewing descaled. (C) Abdominal scale. (D) Leg scale. (E) Wing scale. (F) Egg. (G) Tarsus of hind leg. (H) Barbed bristle from forewing.

Genus *Lepinotus* Heyden.

Lepinotus inquilinus Heyden.

This species is also widely distributed, and often occurs among old books and papers which have not been disturbed for some time. It is sometimes found in dry grass tussocks in the Tasmanian bush. Tillyard (1923, p. 176) states that specimens found in New Zealand have 15 to 17 joints in the antennæ and are usually without forewings. Tasmanian specimens usually possess the forewings and have 26 joints in the antennæ, thus agreeing more closely with the type specimen, in reference to the antennæ of which Hagen (1883, p. 311) states: "ich zähle bei *L. inquilinus* (Heyden's Type) bestimmt 25 Glieder, doch kann noch eines mehr sein."

Lepinotus tasmaniensis n.s.

(Text Fig. 3.)

Female.—Length of body, 1·50 mm.; length of forewings, 0·34 mm.; length of antennæ, 1·23 mm.

Colour.—Body and appendages have a uniform colour, which varies from light-brown to dark-brown in different specimens.

Head.—Large and triangular. Width, including eyes, 0·48 mm.; length, 0·46 mm. Hind margin slightly curved. Surface smooth and clothed with a few hairs. Eyes large and placed at the posterior angles of the head. They measure 0·15 mm. in diameter, and consist of numerous ommatidia. Epicranial suture distinct. Frontal sutures faintly marked. Ocelli absent. Antennæ long, thin, and consisting of 26 joints. The first two basal joints are longer and stouter than the rest, which are short and subequal in length. Each has a whorl of stiff hairs round its distal third. These hairs are slightly longer than the segment. There are no secondary rings. Maxillary palpi four-jointed. The apical joint club-shaped and about equal in length to the second joint. First and third joints very short. The whole appendage is clothed with a fine pubescence and a few long hairs. The styliform appendages are bidentate, the two teeth being almost equal in length (Fig. 3 C).

Thorax.—Prothorax large and visible from above. Clothed with a few hairs. Meso and metathorax separate. Legs pubescent. Tarsi three-jointed. A row of five or six

short spines on the basal tarsal joint. Tarsal claws devoid of teeth, but furnished with a long bristle, which is inserted in the base of the claw. Empodium well developed. The measurements of the leg segments are given in millimetres in the following table:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I.	0·22	0·26	0·087	0·045	0·042
Leg II.	0·23	0·26	0·100	0·045	0·042
Leg III.	0·27	0·34	0·123	0·045	0·042

Wings.—Forewings without veins, and reduced to rounded, tegminised, brown flaps measuring 0·34 x 0·31 mm. On the dorsal surface of the wing are about 50 coarse erect bristles, each of which rises from a rounded socket. Radiating from each socket are seven or eight lines, which meet with similar lines from neighbouring sockets and form a reticulate pattern over the wing (Fig. 3 B). The pattern is seen best in wings treated with 5 per cent. caustic potash solution. One of the bristles measured 0·09 mm. long. Hindwings are completely absent.

Abdomen.—Brown, oval, 0·56 mm. wide, and clothed with short hairs. Long bristles project at the sides of each segment (Fig. 3 A). Supra-anal plate and paraprocts not fused with the last tergite. In specimens treated with caustic potash solution and mounted in balsam, two star-like bodes of a chitinous nature may be seen inside the abdomen (Fig. 3 D). If the internal reproductive organs are dissected out and carefully examined, it will be found that the star-like bodies are attached to the walls of the spermatheca. Hagen (1883, p. 304) has described a similar structure in *Atropos (Clothilla) pulsatoria* (Linn.), and suggests that it is used for liberating the spermatozoa in the spermatophore received from the male.

Habitat.—Trevallyn, Launceston, 11th July, 1933. Not uncommon in dry grass tussocks.

Type.—Holotype in Australian Museum, Sydney.

Lepinotus tasmaniensis resembles *Lepinotus inquilinus* in many respects, but differs from it in the wing-pattern and in possessing chitinous star-like bodies on the wall of the spermatheca.

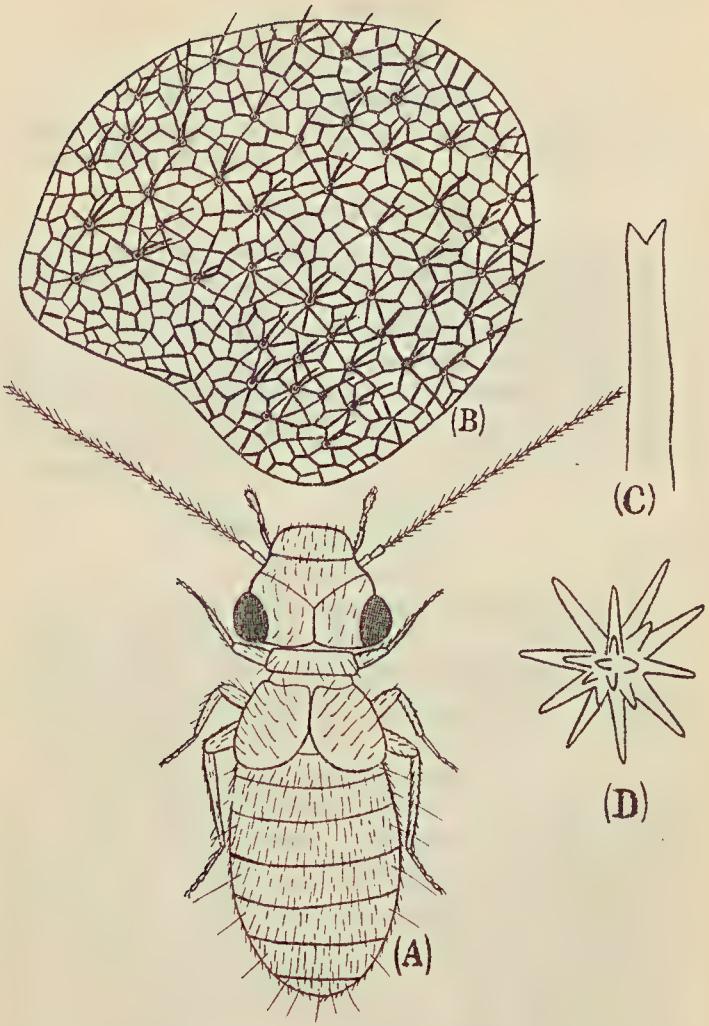

Fig. 3. *Lepinotus tasmaniensis* n.s.—(A) Dorsal view of insect. (B) Forewing, showing reticulate pattern. (C) Styliform appendage. (D) Star-like body on wall of spermatheca.

Family Troctidæ.

Genus *Troctes* Burm.

Troctes divinatorius (Müller).

This small species is plentiful throughout Tasmania, both in houses and in the bush.

Genus *Sphæropsocus* Hagen.

This genus was established in 1882 for the reception of a remarkable Psocopteron found in Baltic amber. It contains only the genotype, *Sphæropsocus künowi* Hagen. This little insect has had a varied taxonomic history. Hagen (1882, p. 230) placed it "zu Atropina." Kolbe (1883, p. 190) placed it in a separate group, Sphæropsocini. Enderlein (1903, p. 208) stated that it belonged to the Psoquillidæ, but later (1911, p. 350) he transferred it to the family Liposcelidæ (= Troctidæ).

Sphæropsocus recens n.s.

(Text Fig. 4.)

Female.—Length of body, 0·94 mm.; length of forewings, 0·63 mm.; length of antennæ, 0·66 mm.

Colour.—Wings, thorax, head, legs, and antennæ very dark brown, almost black. Dorsal and ventral surface of abdomen cream-coloured in the anterior two-thirds. The posterior third is brown.

Head.—Nearly as long as broad. Surface coarsely granular, being covered with small tubercles and a few minute hairs. Eyes small, 0·06 mm. in diameter, consisting of ten ommatidia, and placed a short distance in front of the posterior angles of the head. The interspaces between the ommatidia are covered with small granulations, resembling those on the surface of the head. Frontal sutures indistinct. Epicranial suture well marked. Ocelli absent. Antennæ thin and slightly longer than the forewings. They consist of 15 joints, of which the first two are stouter than the rest. The fourth and fifth joints are much longer than any of the others. Each joint from the third outwards is marked with a series of secondary rings and furnished with a few short stiff hairs. Maxillary palpi four-jointed. The apical joint is elongated and oval in shape, the third joint short, the second joint almost equal in length to the apical joint, and the basal joint very short. The whole appendage is clothed

with fine hairs. The styliform appendages tridentate (Fig. 4 F). The shape of the mandibles is shown in Fig. 4 B.

Thorax.—Prothorax large and visible from above. Tergum and pleura of mesothorax fused to those of metathorax. Legs finely granular and lightly clothed with short hairs. The segments of the legs have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I.	0·15	0·18	0·06	0·03	0·04
Leg II.	0·15	0·17	0·06	0·03	0·04
Leg III.	0·16	0·24	0·08	0·04	0·04

The tarsal claws have an internal tooth before the apex (Fig. 4 E).

Wings.—The forewings (Fig. 4 A) are oval and hard, resembling the elytra of a beetle. They extend laterally beyond the sides of the abdomen and reach to the end of the body, so that the abdomen is completely hidden from above. The venation is considerably reduced. Sc, R, M, and Cu_1 run almost parallel from the base to the apex of the wing. Sc, however, fuses with R near the base. M fuses with Cu_1 at the base and again at the apex. The radial sector is given off from R near the apex, and runs round the margin of the wing to joint the distally fused portion of M and Cu_1. The veins Cu_2 and 1 A appear to be absent. Between the veins the dorsal surface of the wings is ornamented with a reticulate pattern of bordered pits and granulations. There are a few minute hairs along the veins and round the margin of the wings. Hindwings are absent.

Abdomen.—On removing the wings the first two abdominal tergites are seen to be brown and strongly chitinised. Segments 3 to 7 are cream-coloured and soft. In the pleural membrane on each side is a longitudinal fold, in which lie the abdominal spiracles. Only six pairs of spiracles are present. They are situated in segments 2 to 7 respectively. Each spiracle opens on a small brown chitinous tubercle. The tergites of the last three abdominal segments are fused together into a brown, strongly chitinised plate, the posterior margin of which gives rise to a small triangular telson and a pair of latero-ventral paraprocts. On the ventral surface the first five abdominal segments are soft and membranous, but the sternites of segments 6 to 8 are fused into a hard brown oval plate. This plate conceals the genital aperture and a minute T-shaped subgenital plate.

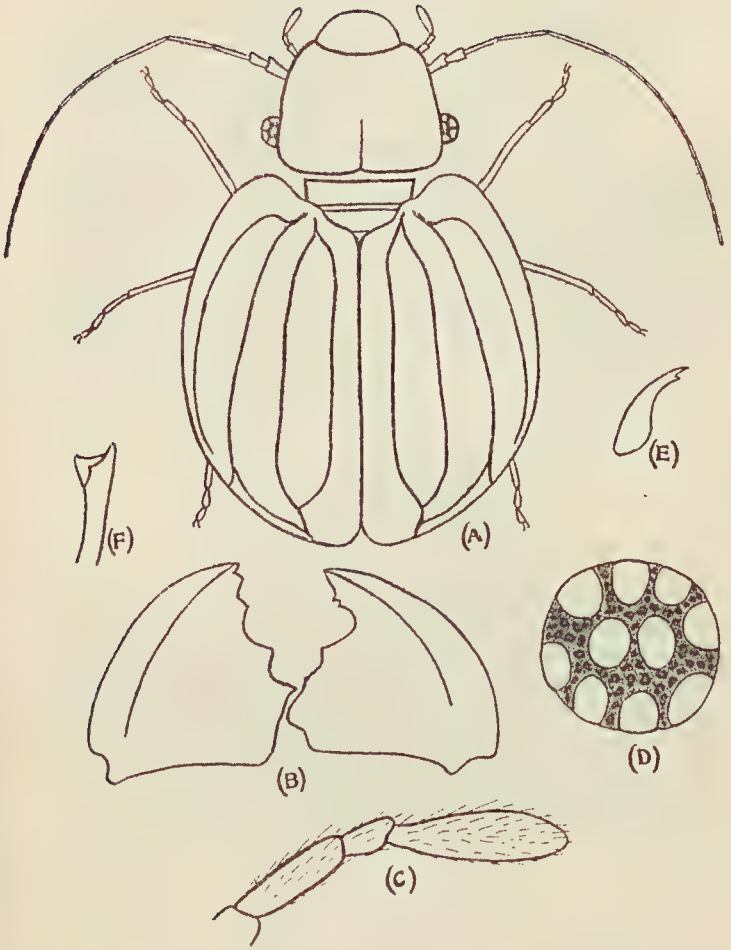

Fig. 4. *Sphæropsocus recens* n.s.—(A) Dorsal view of insect. (B) Mandibles. (C) Maxillary palpus. (D) Eye showing the ten ommatidia. (E) Tarsal claw. (F) Styliform appendage.

Habitat.—Trevallyn, Launceston, 11th July, 1933. A number of specimens were collected from dry grass tussocks on the hills near the Gorge. I have also collected it at Bellerive and on the Domain, near Hobart.

Type.—Holotype in Australian Museum, Sydney.

This interesting little insect resembles the fossil form, *Sphæropsocus künowi* Hagen so closely that it appears to belong to the same genus. The fossil species is stated to have the meso- and metathorax separated. In the Tasmanian species they are fused, the line of union being marked by a deep groove. Apart from this and a difference in the wing venation, there is a striking similarity between the fossil insect found in the Baltic amber of the Lower Oligocene period and the species living in Tasmania at the present day.

Suborder EUPSOCIDA Tillyard, 1926.

Family Myopsocidæ.

Genus *Myopsocus* Hagen.

Myopsocus australis Brauer.

This species has already been recorded from Tasmania by Tillyard (1923, p. 187). It is plentiful under stones among she-oaks on the Domain, Hobart. Large numbers of larvæ, together with adults, may be found during the early part of October. The eggs are laid in masses. They are cream-coloured, and each egg measures about 0·50 x 0·31 mm. The surface of the egg is quite smooth and without pattern. The shape is long oval. Eggs laid on 27th September hatched early in the following December.

Myopsocus nitens n.s.

(Text Fig. 5.)

Female.—Length of body, 2·6 mm.; length of forewings, 2·3 mm.; length of antennæ, 2·3 mm.

Colour.—Head, antennæ, mesothorax, and gonapophyses dark-brown and shining, as if polished. Legs lighter brown. Abdomen light-brown, marked with dark-brown at the sides.

Head triangular, smooth, and clothed with a few short hairs. Width of epicranium between the eyes, 0·46 mm. Epicranial suture distinct; frontal sutures faintly marked.

Three ocelli close together, the median ocellus smaller than the others. Clypeus large and strongly convex. Clypeolus and labrum well developed. Antennæ filiform, consisting of 13 joints. The third and fourth joints are equal in length and much longer than the other joints. Maxillary palpi small and four-jointed, the apical joint club-shaped.

Thorax.—Prothorax small, 0·35 mm. wide, and almost hidden between head and mesothorax. The scutum of the mesothorax is 0·52 mm. wide, and divided into the usual anterior and lateral portions by grooves. Legs with stiff bristles on the tibiæ and on the basal joint of each tarsus. The ventral side of the basal joint of the tarsi of the third pair of legs has a comb consisting of seventeen ctenidia. There are no ctenidia elsewhere. Tarsal claws with a small tooth near the apex and a long bristle at the base. Empodium well developed, enabling the insect to run with ease on the smooth side of a glass tube. The measurements of the leg-joints in millimetres are as follows:—

	Femur.	Tibia.	Tarsal Joints.		
			Basal.	Middle.	Apical.
Leg I.	0·52	0·66	0·20	0·05	0·09
Leg II.	0·55	0·73	0·23	0·05	0·09
Leg III.	0·66	1·07	0·37	0·07	0·11

Wings hyaline, and held at a broad angle over the back. The forewings reach just beyond the end of the abdomen. The wing-membrane punctate. The veins very coarse and dark-brown. The distal third of the pterostigma marked with very dark brown and clothed with a few short hairs. There are also a few hairs along the veins and round the wing just inside the margin. The forewings are blotched with brown, as shown in Fig. 5 A. The hindwings are almost without pigment, except for the basal half of the anterior margin, which is brown. Length of hindwings, 1·8 mm.

The venation has the form shown in Fig. 5 A and Fig. 5 B. It is typical of the genus *Myopsocus*.

Abdomen oval, with its posterior end somewhat pointed. It is clothed with a few short hairs.

Type.—Holotype in Australian Museum, Sydney.

Habitat.—New Town, Tasmania. One adult specimen and several immature forms collected under boards and stones during spring and summer, 1933.

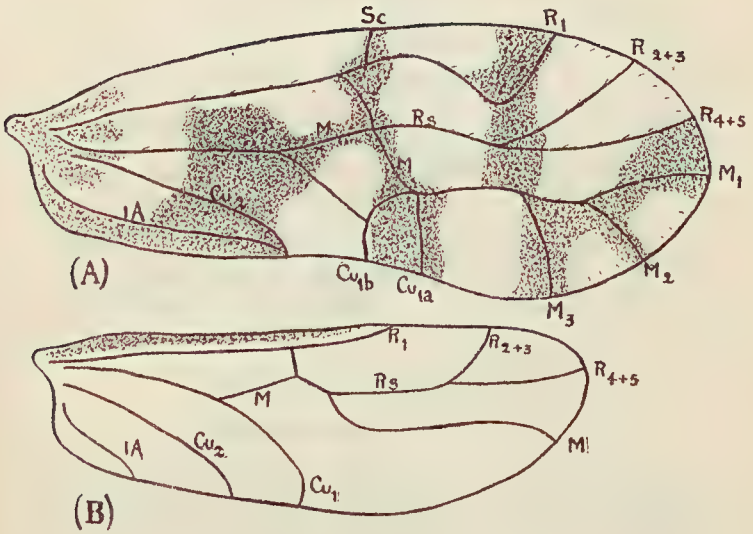

Fig. 5. *Myopsocus nitens* n.s.—(A) Forewing. (B) Hindwing.

Myopsocus nitens differs from other members of the genus in its size, shiny appearance, relatively short wings, and in having the ctenidia confined to the basal segment of the third tarsi. Moreover, it does not congregate in numbers, but is found singly, running about under stones. Its eggs are also laid singly, and not in masses.

Family Cæciliidæ.

Genus *Cæcilius* Curtis.

Cæcilius brunellus Tillyard.

Several mature and immature specimens of this Psocopteron were obtained while beating mimosa shrubs *(Acacia riceana)* along the banks of the New Town Rivulet. It was taken during the month of January.

Habitat.—Lenah Valley, Tasmania.

This species has been previously recorded from New Zealand (Tillyard, 1923, p. 190).

Genus *Ectopsocus* MacLachlan.

Ectopsocus congener Tillyard.

This interesting little species occurs in large numbers under the dry bark of gum-trees. The Tasmanian form agrees very closely with the holotype, both in its wing-venation and in possessing a few small hairs on the veins. Like the preceding species it has been previously recorded from New Zealand (Tillyard, 1923, p. 192).

Habitat.—The Domain, Hobart. Immature specimens collected on 10th June, 1933, were kept on pieces of bark in glass tubes. They spun a fine web over the surface of the bark. Most of them had reached maturity before the end of July.

Genus *Peripsocopsis* Tillyard.

Peripsocopsis milleri Tillyard.

This species was taken among the dry debris and stones at the foot of she-oak trees. It has been previously recorded from New Zealand (Tillyard, 1923, p. 195).

Habitat.—The Domain, Hobart, 17th August, 1933.

Genus *Micropsocus* Enderlein.

Micropsocus nerens n.s.

(Text Fig. 6.)

Female.—Length, including wings, 1·62 mm.; length of forewing, 1·16 mm.; length of antennæ, 1·16 mm.

Colour.—Light-brown. Abdomen with transverse lines of darker brown. Ocelli reddish, surrounded with black rings.

Head triangular, broad, and clothed with short hairs. Sutures well marked. The three ocelli close together, the median ocellus being much smaller than the others. Antennæ 13-jointed, the third joint being much longer than the others. Joints from the third outwards provided with long bristles (Fig. 6 C). Palpi small and normal.

Thorax.—Prothorax hidden; mesothorax with the normal divisions of the scutum. Legs yellowish-brown, clothed with hairs and short bristles on the tibiæ. The bristles each rise from a black socket. Tarsi two-jointed; the basal joint of the hind tarsi with a row of seven ctenidia on its ventral side. Claws small and well curved. The leg-joints have the following measurements in millimetres:—

	Femur.	Tibia.	Tarsal Joints.	
			Basal.	Apical.
Leg I.	0·27	0·32	0·08	0·07
Leg II.	0·31	0·35	0·09	0·08
Leg III.	0·34	0·50	0·15	0·08

Wings.—Forewings extending beyond the end of the abdomen and held in a flat arch over the back. Hyaline punctate and colourless, except at the distal ends of the veins, where there are small cloudy patches. Distal and basal ends of the pterostigma brownish. Veins and wing margin clothed with a few hairs. Venation as shown in Fig. 6 A. Hindwings 0·92 mm. long, hyaline, colourless, and devoid of hairs, except for a fringe of five hairs between the distal ends of R_{2+3} and R_{4+5} (Fig. 6 B.)

Abdomen.—Oval, pointed behind.

Habitat.—The Domain, Hobart, 30th September, 1933. One specimen, collected from a dry grass tussock. When placed in a glass tube it immediately spun a web.

Type.—Holotype in Australian Museum, Sydney.

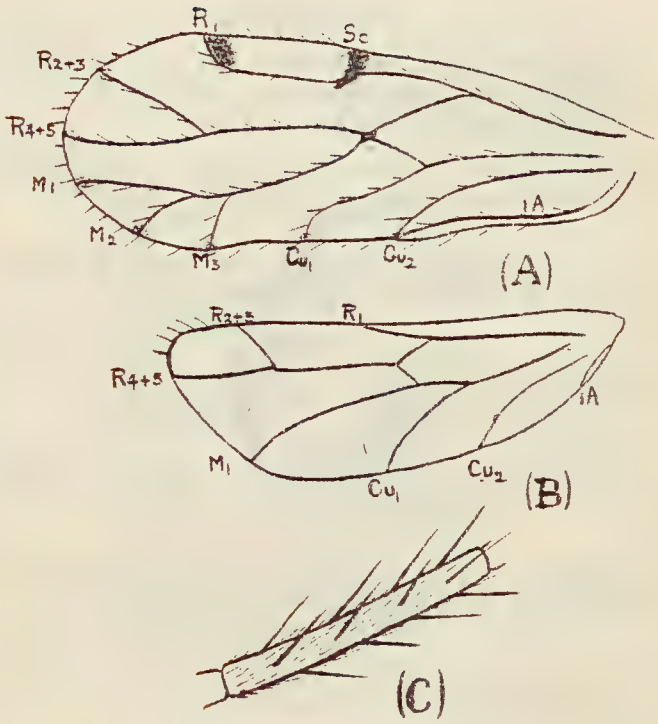

Fig. 6. *Micropsocus nerens* n.s.—(A) Forewing. (B) Hind-wing. (C) Joint from antennæ.

VICTORIA

This species resembles *M. myrmecophilus* Enderlein, but differs from it in colour, in the number of ctenidia on the hind tarsi, and in the relative lengths of the two joints of the hind tarsi.

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The Royal Society of Tasmania

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28TH JANUARY, 1933.

Special Meeting.

A special meeting was held at the Society's Rooms, Dr. W. L. Crowther presiding.

Dr. R. J. Tillyard, F.R.S., Chief of the Division of Economic Entomology, C.S.I.R., delivered a lecture on "Insects Beneficial to Man."

13TH MARCH, 1933.

Annual Meeting.

The Annual Meeting was held at the Society's Rooms, Tasmanian Museum, on this date, the President, Sir Herbert Nicholls, K.C.M.G., Lieutenant-Governor, presiding.

The President announced that he had appointed Mr. W. H. Clemes and Mr. E. E. Unwin to be Vice-Presidents for 1933.

The following member was elected:—Miss D. Nicholas.

The following were elected as members of the Council for 1933:—Mr. S. Angel, Dr. A. H. Clarke, Dr. W. L. Crowther, Mr. W. H. Clemes, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. E. E. Unwin, Mr. F. E. Ward.

Mr. Walter E. Taylor was appointed Honorary Auditor.

Mr. C. E. Lord drew attention to the appearance of a sea elephant at Dunalley, the second occasion in the last few years. He also drew attention to the occurrence of *Ichthyophthirius* in Tasmania, and some discussion followed on matters relative to inland fisheries in Tasmania.

11TH APRIL, 1933.

A meeting was held at the Society's Rooms, Mr. E. E. Unwin presiding.

Drs. Lewis and Crowther congratulated the new Vice-Presidents.

The following new members were elected:—Mr. H. J. Exley and Mr. H. J. Hamilton.

Dr. F. A. Stillwell, D.Sc., University of Melbourne, delivered an llustrated lecture on "The Microscopical Examination of Ores."

8TH MAY, 1933.

A meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Dr. W. H. Robson, Miss F. M. Fuller, and Mr. J. W. Inglis.

The following paper was read:—"The Trout-Food Insects of Tasmania—Part I., A Study of the Genotype of the Mayfly Genus *Atalophlebia* and Its Life History," by R. J. Tillyard, M.A., Sc.D. (Cant.), D.Sc. (Syd.), &c.

Dr. W. L. Crowther delivered an illustrated lecture on "Early Sealing and Whaling in Tasmania," dealing in particular with the research work of the late L. C. Murray.

12TH JUNE, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

The following were elected members:—Miss M. Shoobridge and Mr. W. V. James.

The following paper was read:—"On the Larger Fur-bearing Animals of Tasmania," by C. E. Lord.

Mr. L. Cerutty delivered an illustrated lecture on "Colloids."

10TH JULY, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

Mrs. S. H. Hancox was elected a member.

Col. D. A. Lane delivered an illustrated lecture on "Aerial Forest Surveys."

14TH AUGUST, 1933.

An ordinary meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Madame Harber and Mr. Edwin P. Hart.

Mr. Clemes reported that he and Mr. Unwin had called on His Excellency Sir Ernest Clark, K.C.B., C.B.E., who had notified his willingness to act as the President of the next meeting.

After which the meeting became a

Memorial Meeting to the Memory of the Late Secretary, Mr. Clive Lord.

The Chairman, Mr. W. H. Clemes, referred to the work of the late Mr. Clive Lord for science generally, for the Museum, and for the Society.

Mr. E. E. Unwin supported the Chairman's remarks.

Many letters of sympathy and appreciation from all over Australia were read.

Dr. W. L. Crowther moved, and Dr. A. N. Lewis seconded:

> "That a memorial to the late Mr. Clive Lord be undertaken, and that the Council of the Royal Society be requested to convene a committee to collect subscriptions, and that the committee have power to decide the form the memorial shall take."

The motion was supported by—

Mr. Cyril Taylor, President of, and on behalf of, Hobart Rotary Club.

Mr. J. G. Turner, on behalf of the Sea Fisheries Board.

Hon. L. M. Shoobridge, President of, and on behalf of, National Park Board.

Mr. E. W. Cruickshank, Chairman of, and on behalf of, Tasmanian Field Naturalists' Club.

Mr. A. L. Butler, on behalf of Animals and Birds' Protection Board, and also on behalf of Royal Australian Ornithologists' Union.

Mr. G. H. Evans, on behalf of the Royal Yacht Club.

Mr. J. D. A. Collier, Public Librarian, on behalf of associated educational bodies.

The motion was carried, no one contradicting.

11TH SEPTEMBER, 1933.

A meeting was held in the Society's Rooms, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

The President was welcomed to the Chair by Mr. W. H. Clemes on behalf of the Society.

Dr. W. L. Crowther summarised a paper to be presented to the Society, entitled "Notes on the Habits of the Extinct Tasmanian Race—No. IV., Disposal of Their Dead."

A collection of letters written to James Backhouse was presented to the Society by Mr. E. E. Unwin.

His Excellency presented, on behalf of the Royal Society of Western Australia, that Society's gold medal to Mr. W. M. Carne, Senior Plant Pathologist, Division of Plant Industry, C.S.I.R. The medal was awarded for research in "Bitter Pit in Apples."

Mr. E. E. Unwin delivered an illustrated lecture on "Flowers and Insects—A Story of Adaptation."

9TH OCTOBER, 1933.

A meeting was held at the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Dr. B. Hiller, Dr. W. J. Freeman, and Mr. L. Morrisby.

Mr. W. M. Carne delivered an illustrated lecture on "Problems of Apple Storage."

13TH NOVEMBER, 1933.

A meeting was held in the Society's Rooms, Mr. E. E. Unwin presiding.

Mr. J. J. Westbrook was elected a member.

Mr. W. E. Masters delivered an illustrated lecture on "The Early History of Sullivan's Cove."

11TH DECEMBER, 1933.

A meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The following were elected members:—Miss M. B. Adams and Mr. W. E. Maclean.

The following papers were read:—

(i) "Tasmanian Cycadophyta, Part 2," by H. H. Scott.
(ii) "The Correlation of Pleistocene Deposits," by A. N. Lewis.
(iii) "A Contribution to the Study of Tasmanian Copeognatha," by V. V. Hickman.

The following papers, read before the Launceston Branch, were tabled, and for all purposes of the Society were taken as read before the Society on the undermentioned dates:—

(i) "Notes on Fossil Pine from the Permo-Carboniferous Strata—*Dadoxylon penmani* (sp. nov.)," by H. H. Scott. (24th July, 1933.)
(ii) "On an Unusual Form of Stone from a Tasmanian Native Camp," by H. Stuart Dove. (25th September, 1933.)
(iii) "Notes on a Memorial to Alfred Barrett Biggs, Astronomer," by A. L. Meston, M.A. (25th September, 1933.)
(iv) "Preliminary Notes on a Rock Shelter in Eastern Tasmania," by F. Heyward. (25th September, 1933.)
(v) "Observations on Some Tasmanian Fishes, with Descriptions of New Species," by E. O. G. Scott, B.Sc. (25th September, 1933.)
(vi) "A Note on the So-called Minute Snake of Tasmania," by E. O. G. Scott, B.Sc. (25th September, 1933.)
(vii) "Tasmanian Amphibia in the Museum of Comparative Zoology, Cambridge, Massachusetts," by Arthur Loveridge. (25th September, 1933.)

Dr. A. N. Lewis delivered an illustrated lecture on "The Origin of the Great Lake."

NATIONAL MUSEUM
VICTORIA.

The Royal Society of Tasmania
1933

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President:
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(until 14th August).

HIS EXCELLENCY SIR ERNEST CLARK, K.C.B., C.B.E.
(from 14th August).

Vice-Presidents:
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E. E. UNWIN, M.Sc.

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(Elected March, 1933.)

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CLIVE LORD (until his death on 15th July).

Acting Secretary and Librarian:
MISS JEAN BEATTIE (from 15th July).

In Memoriam

CLIVE ERROL LORD

Editor of this Journal since 1918.

Secretary of the Royal Society of Tasmania and Director of the Tasmanian Museum and Art Gallery, 1918-1933.

Chairman, Tasmanian Field Naturalists' Club.

President, Royal Australian Ornithologists' Union, 1931-32.

F.L.S. C.M.Z.S. F.R.A.I.A.

DIED JULY, 1933.

For a quarter of a century the companion and adviser of all seeking knowledge in the realms of natural science and early Tasmanian history.

He raised this Society from insignificance to the status of a national institution.

He saved for the people of Tasmania their dear friends in furs and feathers and sanctuaries of green and coloured beauty.

He taught the people to appreciate their companions of God's wonderful creation and to share his love of his Tasmania.

THE LATE CLIVE E. LORD.

LC

Clive E. Lord, F.L.S.
1889 - 1933

Clive Errol Lord was the eldest son of Octavius Lord, of Hobart, and a direct descendant of David Lord, one of the earliest settlers in Tasmania. In common with other "foundation" families, the Lords have shared the privilege of rendering their island many notable public services; and the subject of this notice carried on this particular family tradition with distinction.

Born in the last years of the Victorian Period, Lord's span of life permitted him to witness the revolutionary changes of thought and manners which so characterised the first quarter of this century. Lord was the possessor of an active and agile intellect, which denied its owner the comforts of stagnation yet allowed him to successfully adapt his outlook in a period of change.

As early as 1904, whilst a pupil of Hutchins School, Hobart, Clive Lord became interested in the subject of his life's work—the natural history of Tasmania. In that year a small band of enthusiasts founded the Tasmanian Field Naturalists' Club, and Mr. Octavius Lord took his son to the earliest meetings. During the next few years the organised outings of this new association of nature lovers had no more constant attendant than young Lord. As he passed from youth to manhood his interest in the club and its activities grew under the inspired guidance of such leaders as Leonard Rodway, and from an old Club programme of 1911 we learn that Lord had by that year reached the Honorary Secretaryship, the principal position in the organisation.

On leaving school Lord entered the office of a well-known Hobart firm of architects and engineers, and following the completion of his articles he set up in practice as an architect on his own account. It often came as a surprise to those who only knew him in the later stages of his career to learn that he had at one time actively practised as an a hitect. There is little danger in the surmise that had Lord remained in his profession he would have eventually

become a distinguished member because of his power of adaption and scrupulous care for detail.

In 1917 the Trustees of the Tasmanian Museum, to the surprise of the outside public, appointed the young architect to fill the vacant position of Director (or Curator as it was then known) of their institution. The wisdom of their choice soon answered any misinformed criticism; in a very short time Lord demonstrated his ability to administer an important, if somewhat neglected, public institution.

During the years which preceded his Museum appointment Lord had undoubtedly done some very useful work for the cause of natural history and natural science in Tasmania. He had built up the Field Naturalists' Club until it was probably the most active, if not the largest, of its kind in Australia; the standard of its meetings was high, and scientists of national eminence attended its Easter camps on the Tasmanian south-eastern coast. But more important still, the energetic " Hon. Sec.," as he was affectionately known, had succeeded in persuading an indifferent Hobart public that they lived daily in the midst of many remarkable manifestations of Nature. Clive Lord possessed the faculty of interesting all manner of people in the subjects he had at heart. Somehow or other Lord found time in those strenuous days to compile and publish a small guide to the study of Tasmanian bird life.

So far it has been possible in this brief space to deal with the subject's career in something of chronological order. To apply such a method to the remaining period of his life (1917-1933) is scarcely practicable; the Director of the Tasmanian Museum had literally dozens of interests and enthusiasms.

The subject which kindled a great enthusiasm in Clive Lord was the study of the voyages round the Tasmanian coast of the sea explorers. A keen yachtsman, with an interest in hydrography, he was able to follow the old sailors' logs and charts as no " desk " historian could. Lord's little book, " The Early Explorers of Tasmania " (1920), has achieved the eminence of a standard work on the subject. Directly as the result of his researches Tasman, Cook, Furneaux, Bligh, D'Entrecasteaux, Baudin, and Kelly have been set in their proper background in Tasmanian history.

Lord's meticulous regard for historical accuracy and his generous share of moral courage proved not a little disconcerting to his opponents in the public controversy

which followed the erection of the Tasman memorial in 1923.

A deep sense of public duty and a rare love for upspoilt Nature brought Lord to the forefront of the movement which secured a National Park for Tasmania. Whilst others secured the park area, it was Lord, as secretary to the administrating body, who directed the opening up, the real making of the park and natural reserve. It is easy to understand that he was a leader in the later movement which secured the scenic reservation of the Lake St. Clair-Cradle Mt. area.

A public conscience is a hard task-master, and in obedience to it Lord took a very active part in the formation, and later the administration, of the official boards which were set up to regulate the fur-trapping and fishing industries in Tasmania. Again, he took a lively and very practical interest in such local organisations as the Hobart Development League, having civic development as aims. The humanitarian instincts of the man found some satisfaction in the activities of the Hobart Rotary Club, of which he was a foundation member.

The rapid advance towards extreme specialisation in science did little to alter the direction of Clive Lord's researches; from first to last he was a naturalist in the widest meaning of the word. For a number of years the vertebrate animals of Tasmania absorbed his attention, but not to the exclusion of the study of other natural phenomena. Shortly after his appointment to the Tasmanian Museum Lord added to his steadily growing list of publications in the form of a little work on the snakes of Tasmania. This was only a prelude to greater things to come. Sometime about 1920 he commenced an association with Mr. H. H. Scott (Curator of the Launceston Museum) for the purpose of describing the island's vertebrates in the light of modern knowledge. Their joint work soon yielded profitable results; the publication of their observations on certain extinct forms of life in Tasmania attracted international attention, and Lord, as the leader of the work, was honoured with the "blue ribbon" of natural science, election to a Fellowship of the Linnean Society. In 1924 the two investigators published the results of their work in a volume entitled "A Synopsis of the Vertebrate Animals of Tasmania." Some years later the Royal Society of Tasmania presented Lord with its own medal—the exacting conditions

for qualification for this honour having been fulfilled. Some indication of the man's standing in the Australian scientific world may be drawn from his selection as one of his country's representatives to the centenary meeting of the British Association in 1931.

No notice of Lord's career can be adequate without some reference to his labours for the Royal Society of Tasmania and the Australasian Association for the Advancement of Science. He held the position of Secretary to the Royal Society from 1918 till his death. During that period he brought the same enthusiasm to building up the Society as he had to the Field Naturalists' Club. His record in this respect will be very difficult to equal. Lord undoubtedly possessed a gift for the organisation and piloting of scientific bodies, and he gave a notable demonstration of his abilities in his direction of the Hobart meeting of the Australasian Association for the Advancement of Science held in 1928.

Clive Lord's breezy, good-natured personality will remain a life-long memory to all who came into contact with him. His many interests and enthusiasms often made him inclined to be impatient with others of lesser warmth and energy. His bountiful fund of humour and easy companionship made him much sought after by his fellows. Clive Lord was one of those rarer individuals who cannot be judged by the higgling values of the market-place.

JOHN REYNOLDS.
(1934.)

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R. M. Johnston Memorial Lecture

Science and Sea Fisheries with special reference to Australia

By

WILLIAM JOHN DAKIN, D.Sc., F.Z.S.

Professor of Zoology, University of Sydney, N.S.W.

With 2 Plates and 3 Text Figures

(Read May 30th, 1934)

FOREWORD

One of my very worthy predecessors has indicated in his inimitable way the difficulties which face anyone honoured by election to deliver a lecture which has been instituted to bear memory to a great pioneer. There is to my mind always much difficulty in framing those lectures which are expected to do justice to a seat of office. The task is, however, immeasurably greater when a lecture is to serve as an offering in memory of a great man. The best I can do is to choose a subject close to my heart and I have selected one associated with the sea for I was first trained in a school of Marine Zoology at a University in a great seaport—that of Liverpool in England, and since I was by nature fond of the sea, my investigations have practically always been associated with marine problems. Whether the work was what some would call of pure scientific value or not, it has almost always been intimately connected with fishermen and fishery problems.

I make no apology, however, for selecting a subject associated with the sea and its products. The history of Hobart Town itself, its early pre-eminence in whaling and shipbuilding, is fortunately somewhat familiar to me. Is not this the obvious place for discoursing on sea products? But that is only to provide the background. The man whose memory we honour this evening was one of Tasmania's pioneers in the fishery problems. For several years he was a member of the fishery boards. He was the author of a number of papers on fishes. Moreover, if it were Johnston's hobbies—geology, zoology, and botany—which claimed the attention of his brother scientists, may I say that Biological Science to-day is becoming in many fields a statistical science, as you will see tonight. R. M. Johnston's life work was that carried out as the pioneer Government Statistician for Tasmania.

I render my homage gladly and humbly to his name. Australia has urgent need to-day of servants with such broad outlooks.

Introduction

I need not labour the point that Applied Science has changed the world completely in the last century. There are some who say for the worse. It is very difficult to see how that idea can be upheld if even a cursory observation of current economic problems is made. Any discoveries reducing the demands for labour in one field are, or should be, balanced by discoveries and inventions which have required more labour in other fields. The increased production in wheat and other foodstuffs cannot honestly be claimed to have resulted in over-production whilst thousands remain underfed. Again, the discoveries of medical science have removed altogether many horrors of life; and it would almost be ridiculous for me to try and tabulate the results of discoveries in, say, the field of electricity. Rather would I suggest that it is man's business organization that is at fault in these hours of trial, and especially his political systems. The world is almost controlled as if modern science had never existed, and by those who are still the products of an ancient educational system, ignorant of scientific method, although every day the effects of science lie plainly before our eyes.

In no branch of modern life has science played a more important part than in its relations with our food supplies. It has enabled the farmer to grow far more than two ears of corn where only one grew before and in addition has aided him in battling with drought and crop diseases. We have discovered the mechanism of heredity and the laws to be observed in breeding animals. We have learnt how to preserve our food, to convey it from one end of the earth to the other. We can make up the deficiencies in the soil by chemical products, so that there is food enough for richer plant growth, and we are still seeking better and better means of economically nourishing our live stock. The great science of Agriculture with its sister branches of knowledge is now represented in our universities and farm schools.

There is one great area of the earth's surface, however, where we reap without sowing, indeed in most places without knowing how best to reap, and whether we do it wisely or dangerously. That area is represented by the Sea.

There was a time when man neither cultivated crops nor worried overmuch about the extent of his hunting. But long before history left us anything in the way of records, the culture of plants and the domestication of animals had been practised. Before the dawn of modern science man had obtained much knowledge along these paths.

As concerns a similar investigation of the sea we are still only moving out of the primitive stages. We in Australia are particularly backward and in many respects scarcely out of an unusually primitive hunting stage.

It has been carelessly said that Australia has the greatest fishing coast in the world. In what way is this true? Taking the whole

of our coast into consideration and estimating the area between it and the 200-fathom line, the result is 644,000 square miles. Of this probably 65 per cent. lies north of the latitude of Rockhampton, 23½° S. (in Queensland.) We are left with 145,385 square miles if we take the fishing area off the coasts of New South Wales, Victoria, Tasmania and South Australia. Now the trawling grounds alone of Europe are well over 680,000 square miles in area, that is to say, greater than our whole total, and these are all proved fishing areas. (The Mediterranean is completely left out in this calculation.)

As regards Australian production we have been told (Reports of the Australian Fisheries Commission, 1929) that the fishery of Victoria is confined almost solely to the bays and inlets along the coast and that these are now fished to capacity. Yet there is practically no deep water fishery off the East Victorian coast except what is carried on by a few Sydney trawlers. The fishery of South Australia again is chiefly in the St. Vincent's and Spencer's Gulfs and is equally the result of small scale fishing. The Great Bight remains more or less a *mare incognitum*. The Tasmanian fisheries are mainly those of the south-east, extending from Recherche Bay to Schouten Island, based on Hobart, and the other regions such as the west and north-east are said to be hindered by bad weather or lack of transport facilities. That excellently situated region of sea, the Bass Strait, is supposed to be relatively unproductive. Like most other areas the Tasmanian fisheries are also mainly served by hand lines and seine nets.

The fishing industry of Western Australia is as primitive as those of the States mentioned above and even more localized. Only in New South Wales has an effort been made to use the methods of large scale commercial fishing, but even here as much fish comes from the estuaries and other land-locked waters as from the ocean fisheries and the inshore fisheries employ about one thousand eight hundred persons directly as against say 200 on the deep sea trawlers.

Now the N.S.W. trawlers have only been at work 19 years, yet during the past five years the captains have complained of scarcity of fish and the voyages have increased from three or four days to seven or eight days. Are the complaints justified? If they are, can the matter be explained? Has over-fishing already resulted in depletion? I bring this last query into my introduction because the first stimulus for the application of science to Sea Fisheries may be traced to the origin of a similar fear of *depletion* in other parts of the world where catches appeared to be falling off. The initiation of a scientific study was not due to a desire to *increase* the yield of the sea beyond its previous fertility, but to explain diminutions and then, if possible, to bring the fertility back to that which was supposed to be the original state.

In Australia we are in the position that most of our fishing areas are still unknown and rest almost in the virgin state, crying for

exploration. Yet, as if to emphasize the need from the outset for information along scientific lines, the only sea area which has been seriously worked already presents problems and alarums.

I do not intend to trace the history of the world's *great* fisheries here. It will be sufficient to note that the dawn of a new era came with the application of steam to fishing vessels and the tremendous development of trawling in the nineteenth century. Trawling as a well-defined mode of fishing in the North Sea expanded gradually during the years between 1800 and 1860 but it was after 1880 with the utilization of steam trawlers, that events moved faster, to culminate with the discovery and adoption of the otter trawl after 1895.

Of course biological discoveries of some importance in regard to fisheries were made before the comparatively recent dates I have given here, because there were zoologists interested in the sea and its life from the time of that great pioneer Aristotle. Indeed one of the outstanding scientific discoveries bearing upon fisheries was that of Professor G. O. Sars of the University of Christiania, who discovered in 1864 that the eggs of the cod fish, and other important food fishes floated in the surface waters of the sea after extrusion and fertilization, and underwent their development until hatching took place in these surface waters. Yet even now it is a popular belief on the part of fishermen that the sea fish lay their eggs on the sea bottom where they are destroyed by trawlers.

Complaints about over-fishing in the North Sea came to be potent about 1863 when the English Government appointed a commission to enquire 'whether or not the value of the fisheries was increasing, stationary, or decreasing; whether or not the existing methods of fishing caused permanent injury to the fishing grounds, and whether an extension of existing legislation was necessary.'

Allegations that trawls destroyed the eggs of sea fish and that depletion was occurring were again brought before an English commission in 1878. Between these dates, however, German scientists became more directly interested in sea-fisheries, and in 1870 the Royal Prussian Commission for the Scientific Investigation of the German Seas was established—the first definite organization of science in its application to sea fisheries. Other countries were close together in this evolution of interest in sea fisheries. Supposed depletion had just occasioned the appointment of a Fisheries Commission in the United States and a Report was issued in 1871 on the decrease of food fishes on the Coast and in the Lakes of U.S.A. This Report is particularly interesting for the consequences which led to the formation of the United States Bureau of Fisheries and the application of science on a larger and better organized scale than anywhere else.

The wave of inquiry seems almost to have been world-wide about 1865-1875, and even in 1870 it is said that Dutch herring boats were supplied with thermometers and notes relating to their use, because it had been discovered that more herring were caught at temperatures between 12° and 14° C. than under other conditions. The Russians, too, were making researches in the Baltic and the White Seas. The first British effort on a serious scale came with the Scottish Fishery Board's inquiry in regard to Herring towards the end of the 'seventies.

Fishery Boards in Scotland were years ahead of England in their activities. Scotland was not only collecting information as far back as 1850-1860 but was encouraging scientific investigations. (Natural History of Herring 1843-47 by Goodsir and Wilson. Herring Eggs, Dr. Walker 1803.) Huxley himself devised forms for the tabulation of fishery observations in 1856. All this was desultory, however, until the reconstituted Board of 1882 stated that 'without further information as to the habits and life history of the food fishes, it would be impossible to submit satisfactory Reports to Parliament, either as to the improvement or as to the regulation of Fisheries.'

England had no fisheries department at all until 1886 and its activities were scarcely worthy of note for many years. Scientific investigation was developed, however, sporadically by certain of the Fishery Committees which were responsible for the control of different parts of the English coast. It was practically dependent on the private interest of a few scientists of note, one or two semi-private biological stations, and the Marine Biological Station of Plymouth whose fine record of work from 1884 onwards is well worthy of mention. The English Marine Biological Association might be regarded as the official advisor to the Government during that period.

In the year 1899 the Swedish Government invited Government representatives from Great Britain, Germany, Denmark and other European countries to meet at Stockholm for the elaboration of a joint scheme of exploration of the seas in the interest of sea fisheries. Out of this arose the *Permanent Council for the Investigation of the Sea* which has instituted many researches into hydrography and marine biology and whose publications are of the greatest value. In these works the shading of so-called pure and applied science into each other is very evident.

Anyone interested must look elsewhere for the history of all these and other organizations. My purpose in this brief account is merely to suggest the atmosphere in which the need for inquiry arose. To a considerable extent this enveloped a demand from one section of fishermen for legislation against another; the conflict of those pursuing one kind of fishing against some method of fishing used by their brethren, which was supposed to be causing depletion. A unifying feeling if present in the fishing fraternity was due to a rooted objection to legislation of any kind on the grounds that it

was wrong or useless to interfere. And boards of enquiry had often to admit that they knew little or nothing on which to base the laws.

In these ways, then, our history of Fishery Science commenced 64 years ago. It was a lucky chance that in those happy pre-war years I met at Kiel, and Heligoland, all the German commissioners, Hensen, Brandt, Reinke, Krümmel and Heincke, the members of the very first organized body for the development of fisheries science. Their work was well and truly aimed at the fundamentals.

Suppose, however, one glances through the whole mass of literature which has resulted from the development of the various bodies to which reference has been made—what is the general impression of the condition of Fisheries Science, of its aims and its achievements, of its methods and its requirements? How do we stand in Australia and what attitude should we take to this sort of research? It is to find the answers to these questions that I have set myself in this address.

The first impression made by much perusal of Government and other documents is that, considering the amount of research which has been conducted under the auspices of fishery commissions, a considerable amount of energy has been wasted on non-essential work. I must be careful about this criticism because no one realizes better than myself how exceedingly difficult it is to draw the line between pure and applied science. This was recognized at the very initiation of the United States Fish Commission when it was asserted that the life histories of the fish could not be complete without a thorough knowledge of their associates in the sea, especially of those which form the prey of, or which prey upon, the fish population. Unfortunately fishermen, pseudo-experts and politicians have all been far too ready to step in with criticism somewhat similar to that of mine above—albeit far more embracing, and with nothing to support it.

Fisheries science involves very adequate knowledge of many cognate sciences. To understand the phenomena of growth, migration and reproduction of any particular species of fish, necessitates the co-operation of biologists, physicists, chemists and hydrographers. It is quite easy to understand why the fisherman or the man in the street cannot see the necessity for investigating, say, the minute floating life (the plankton) of the sea so long as he is altogether ignorant of the elementary facts about such work. Yet, whilst impatient of general criticisms, and of the lack of understanding on the part of these people, I feel bound to stress the fact that *experiment* has lagged far too much behind *description* in zoology. Elaborate descriptive catalogues of starfish and medusae *may* at some time play a part in our control or understanding of the marine environment, but the enormous output of purely taxonomic zoology has overshadowed other work of fundamental importance. Fortunately there is a new spirit in zoological science amongst the younger school today.

Sea fishery does not at present bear any resemblance to Agriculture for it only represents the harvesting. And the first prime essential, which has been recognized by Governments everywhere—even by the Governments of Australian States—is that Fisheries must be conserved. That word '*con*served' I shall suggest means something a little different from the more frequent term '*pre*served'. I suggest that it implies that whilst fishing shall take place and full use be made of the natural produce of the sea, it should be regulated in such manner that the natural yield is at least upheld. If methods of increasing the yield can be discovered, so much the better.

And here I may suggest that the fishing industry above all others requires the attention of Government. It is most akin to agriculture but its claim for help is even greater, for the farmer may at least hope to own his land, and what he does with it does result in benefit, (or the converse), to himself, as well as perhaps to the country. But the sea fishermen have no claim either to the sea floors, or the surface waters. Force of circumstance in the past has driven the hardy fisher folk of the northern hemisphere to invent their own gear and even to explore remote icy seas to obtain their profits. But in a country like Australia (where there is no time for this century-long growing-up process, and the slow evolution of older populations), I can scarcely visualize a public company spending large sums on the exploration of new fishing grounds when they know that the results are going to be available to anyone else who likes to use them.

The Methods of Fisheries Science

Biometrical methods

As I have indicated above, the first step in the application of science to fisheries is the obtaining of knowledge of the fishery stock and something definite about its productivity. Starting off from this point we are at once faced with the following questions when taking stock of the fish production of the sea.

(1) Is there over-fishing?

(2) If over-fishing is taking place how can it be avoided?

Round about these two questions revolve many different branches of Fisheries science.

In order to answer the first question, methods must be devised to determine:—

(*a*) Some idea of the natural resources of the region of the sea under consideration and the proportion of the fish caught to the natural production in the same time.

(*b*) Whether *natural fluctuations* in yield occur quite apart from anything which may be due to human influence, and what may be the relative force of nature as compared with human interference.

(*c*) Whether definite reduction in the number in the sea of one type of fish—either species or size class—is really a bad feature.

(It has been said, for example, that overfishing of large sizes may result in more fish food and consequently faster growth and greater production on the part of the smaller sizes.)

The second question set out above involves firstly the problems of fish hatching and fish-rearing. Is it possible to perform such operations commercially and can over-fishing be balanced by such means? Another possibility of enrichment also exists by the transplantation of small fish from one area relatively rich in small fish but poor in food supplies to another area rich in the latter but removed from the breeding grounds of the species. These lines of investigation bring along in their train the following necessary studies:

(1) The acquirement of a full knowledge of the life histories of the species of commercial fish involved, from the egg stage to the adult, their feeding and breeding habits, and their migrations.

(2) A knowledge of the marine environment—its physical, chemical, and biological characteristics.

The difficulties of the biological problems are extremely great, however, and the fishermen and others interested must realize this at the outset and properly evaluate the work of the scientist—an attitude which is rare, except possibly in Japan and the United States. It has taken a very considerable expenditure to date to determine the exact habits of the Australian blowflies and the best methods of restricting them, yet unfortunately with little practical success so far as the latter object is concerned. Living things are not so easy to control or remodel as machines, or articles of wood and iron. And living things in the sea present the additional difficulty that usually they cannot be seen until caught. Their very capture involves difficulties and increased expense. The area of the earth involved in sea fisheries brings further trouble—fisheries are not usually tied down to a small district; and eggs spawned in one region may drift far and grow up in another quite distant place.

There is no doubt that the first step in the general investigation of a fishery involves the institution of methods for capturing fair samples of fish from the sea and the establishment of statistical methods for dealing with these samples. By the application of the correct methods, information can and should be obtained regarding (1) the number of fish of any particular species in a catch of definite duration—time and locality being accurately noted; (2) weight of fish; (3) lengths of fish for age determinations, also scale samples; (4) sex and degree of development (to be correlated with length, age, and season); (5) contents of alimentary canal.

Fishery statistics devised for operating on such information are, however, not by any means simple. Commercial statistics may, if taken honestly, supply some valuable information indicative of the fluctuations in the sea. For this purpose, however, information is necessary regarding the source of the captures (which very often

trawling captains or owners refuse to divulge) *and the duration of the hauls,* so that eventually one can determine a most important figure—the catch per a unit of time—sometimes set out as the catch per day's absence, better and more definitely worked out as the catch per 100 hours fishing.

For example, in 1924 the catches of English trawlers worked out as follows for 100 hours of trawling:

In the North Sea 122 cwt.; in the English Channel 101 cwt.; South of Ireland 246 cwt.; but the Barents Sea gave 890 cwt. and Iceland 1027 cwt. New South Wales trawlers have never reached such high figures as are reported for the Barents Sea and Iceland, but occupy an intermediate position, with 430 cwt. in 1919, 443 cwt. in 1921, and 470 cwt. (probably the highest average reached) in 1922. Unfortunately the present figures which will be referred to later give yields which are only 290 cwts. or thereabouts.

A serious difficulty in addition to those raised above is that in any long period of yearly comparisons the catch per 100 hours may be invalidated owing to changes in types of fishing gear or methods of fishing. Yet it is these long series of statistics which are valuable. The statistics of the northern hemisphere which go back some years before the war are not altogether comparable with ease because the types of fishing gear have changed. This difficulty may be allowed for with care. For the greatest accuracy there is no possibility of working other than with special research vessels whose gear can be controlled for the special purposes in view, but this makes investigation costly and limited. There has been considerable difficulty in obtaining fishery statistics which can be utilized for the purposes indicated above and from which observers can deduce all that science has shown possible. It is obvious that the taking of length measurements may often necessitate scientists or trained observers working at sea on research or commercial vessels. The catches brought to market by commercial vessels do not even represent fair samples of the catch taken—all small fish having been thrown overboard.

At the Pan Pacific Conference held in Honolulu in August 1920 the Government of Australia (with Japan, New Zealand, Canada, U.S.A. and Hawaii) was recommended to collect systematic statistics of the fisheries and publish them annually. Nothing has been done and fourteen very important years have gone since then. At present we lack valuable fundamental information as a result of this for the Australian statistics indicate merely the amount and value of fish landed. And they do not even allow any attempt at discovering the catch per 100 hours fishing or the catch per day's absence from port.

Now let us see what biometrical work may accomplish. The statistics of the Plaice Fishery of the North Sea form probably one of the best examples the world can provide of the difficulties

in the interpretation of fishery statistics. It is worth while, therefore, to utilize this example as an illustration.

From 1906-1913 there was every indication that the North Sea was being harvested to the fullest extent. 671 *first class* fishing boats were on the register of Grimsby alone in 1914, and taking Grimsby, Lowestoft, Hull and Yarmouth together the number was 1883. All these boats did not fish in the North Sea but we have not counted the Scandinavian, French, German and other vessels which did. The total yield of plaice per day's fishing per boat averaged about 2·1 to 2·5 cwt. and although the fullest statistics were not available for early years there seems no doubt that there had been a very big drop in the day's catch per vessel.

Now the war years effectively closed the North Sea to fishing—a close season was brought into being that no amount of peaceful international agreement could have accomplished. The fish were left alone on their banks except for the occasional explosion of mines and depth charges. At the end of the war—1919—the first trawlers to get to work captured 4·5 cwt. of plaice per day's fishing, nearly double the pre-war amount, so the change was *easily* noticeable. Moreover it did not require any statistical evidence to show that hauls of unusually large fish were being easily obtained.

The figures of the statisticians showed, however, that this did not mean that the numbers of all sizes of plaice had increased. Actually there was a reduction in the proportion of the small fish present in the catches. Thus, figures representing the relations of large, medium, and small, run as follows:—

	Large	*Medium*	*Small*
1913	5	8	10
1919	9	13	2
1920	13	12	5
1921	6	11	6
1924	2	5	13

A scientific explanation was put forward to explain these surprising figures. The possibility of making such an explanation was, however, entirely due to the previous work of certain investigators—in particular Heincke, on the age determination and rate of growth of the species of fish in question. I shall digress for a moment and consider the technique of such research, which forms an important branch of fishery science.

From the beginning of the more serious scientific efforts to determine the productivity of any area in fish and the results of man's attack on such an area, it has been obvious that no accurate solution to the problems could be hoped for without information regarding the ages of the fish of different sizes caught, and also of their rate of growth.

One of the earliest successful methods of age determination was invented by the Danish scientist, C. G. J. Petersen. It is a statistical method dependent upon the breeding season of the fishes for which it is used, being limited to a more or less short period of the year.

If the lengths of a large number of individuals of the species in question are taken and tabulated, they will be found to fall into distinct groups. A curve depicting the lengths may be a many peaked curve, each peak being the mode of frequency of a class. And the *difference* in length between the mode of each class represents the increase in growth which has taken place in a year. Figure 1 represents such a curve for the Tiger Flathead taken by trawlers off the coast of New South Wales between the 12th August and the 2nd October, 1930.[1] Peaks occur at 24, 32-33, and 42 centimetres.

Unfortunately, where this method has been utilized very considerably it has been shown that it is only applicable to the younger and more actively growing year groups of fish. It is also open to other errors since the rate of growth may be very seriously influenced by local environments (there may even be local races which normally differ in character), by favourable conditions, by plentiful nutriment or the converse, starvation. The method is, however, very useful especially when it can be checked by other means.

There is another method of age determination which depends upon the rings of growth which occur on scales and other skeletal features, particularly on the auditory ossicles. The first to show that scales could be utilized accurately in this way was Hoffbauer using the Carp, and Thomson of Plymouth, with the Haddock, 1902. The otoliths were utilized by Reibisch in 1898, and then Heincke showed that almost all the bones of teleost fish showed definite rings of growth which could be clearly associated with annually recurring different seasons—the alternation of summer and winter—quick growing and slow growing periods of the year. If it can be shown that one ring is added per year and the age of the fish at the deposition of the first ring is known, the age of any fish of the species should be determinable by scale or bone examinations.

This method has been proved reasonably accurate in many cases by comparing the results of scale readings with the results of the Petersen length technique. The simplest demonstration of course is that by making direct observations on fish which are cultivated in ponds or aquaria. Another important method of checking scale readings is one which can be associated with the marking of live fish in connexion with the study of migration, etc.

In such marking experiments, fish tabbed with characteristic 'badges' are set free, after the length of the fish and character of the scales have been noted. If such fish are captured, say a year or more later, there should be additional scale rings to correspond with the increased age. The increase in length will give directly the rate of growth. Such marked fish which have been recaptured

[1] During the year 1930-31 35,000 Tiger Flathead *(Neoplatycephalus macrodon)* were measured by my colleague, Mr. A. N. Colefax, B.Sc., on trawler voyages.

have demonstrated sufficiently well the accuracy and usefulness of scale readings.

Up to date, however, most of the scale reading methods have been used in the cooler temperate seas and whilst they are clearly applicable to fish of Tasmanian waters (I have had scales of

Fig. 1.—Curve depicting frequencies of Tiger Flathead of lengths between 14 and 62 cms. taken on three cruises during Sept.-Oct., 1931. (From data of A. Colefax).

Trumpeter and other species sent me by the late Mr. Clive Lord) and I have reason to believe are probably applicable to certain fish species of New South Wales waters, they may be altogether uncertain in our more tropical waters.

We can now return to our North Sea example of fishery statistics. The results of scale readings not only showed that the large post-

war plaice were *old* fish, but that *the smaller sized fish did not correspond in age to pre-war fish of the same length. They were older.* In other words the post-war plaice were growing more slowly than the pre-war plaice.

The average lengths and ages for pre- and post-war plaice are given by Fr. Heincke and Ad. Buckmann as follows:—

Age Groups	I	II	III	IV	V	VI	VII
Average Length in Centimetres—							
1905-6	15	19	23	26	30	32	38
1922	14	16	19	22	25	29	32

An explanation of the above figures was offered as follows:[1]

As a result of the war-time cessation in fishing, large numbers of plaice increased in age and consequently in size. The result of this was a crowding of young fish on the bottom in certain areas with a resultant diminution in the rate of growth—possibly through reduction in the food supply available. We might regard the North Sea as having thus returned (more or less) to the original condition of virgin grounds.

The first result of the discoveries given above was that the German experts, and certain English workers, regarded the whole matter as an absolute proof of the need for restriction of fishing in the North Sea and evidence of the necessity for international regulation. Plans for such were put forward.

There were some, however, who interpreted the figures otherwise. The late Professor James Johnstone of Liverpool, for example, claimed that in the Irish Sea the variability in size and abundance of plaice during the years 1892-1920 was something that happened of itself—'Quite apart from the influence of the fishing fleets.' Throughout the period there was good evidence of a natural fluctuation in the abundance of plaice, some series of years being good, while others were relatively bad.

If this explanation were applied to the North Sea we should have to believe that the increase of plaice during the war years was *just* a coincidence and little or nothing more. Those who were most familiar with the North Sea did not accept the probability of such a coincidence.

The next step to be noted was a remarkable falling off in the plaice catches in the North Sea in the successive post war years 1920-23. The war-time accumulation of fish seemed to be removed in an amazingly short time. It could not be explained away simply

[1] See H. M. Kyle. 'Die Statistik der Seefischerei Nord-Europas.' *Handbuch der See-Fischerei Nord-Europas.* Bd x. Heft. 4. 1928.

by renewed overfishing. So Borley and Thursby-Pelham in 1924[1] found themselves compelled to state—

'that causes due to natural conditions must also have been at work. The acceptance of the proposition that both human and natural agencies are at work is of the greatest importance. Had the natural causes alone appeared responsible, the regulation of the fishery could not hope materially to influence the prosperity of the fishery. Had the reverse been the case, well-planned remedial measures could have produced their effect without hindrance. If the conclusion here reached be accepted, it follows that in part the industry must abide in patience the vicissitudes due to natural causes, but that there is a wide margin in which measures properly based on the facts of the life history of the fish and the knowledge of the destruction caused in fishing should have their reward.'

We have in fact reached a point of the greatest importance after long years of statistical work—the certain evidence that a scientific survey of fisheries must recognize and study the natural fluctuations in abundance which are now known to be characteristic of fish populations. An amazing amount of fishery research today is concerned with these natural fluctuations. In fact this study represents the front of modern fishery research.

This, however, is not all that may be deduced from the example we have chosen—North Sea plaice fishery statistics. We have seen that one school has demanded protection of the region from the 'over-fishing' that is assumed to be taking place. Naturally there is opposition from fishery interests. There is also disagreement on the scientific side. The most desirable treatment of any fishery area is shown to be anything but the simple problem in view at first. Just as on land there may be such a thing as overstocking.

We may aim at the production of a large number of large fish. We may aim at the greatest propagation of fish flesh in the shortest period of time.

The two things are entirely different. As Johnstone pointed out—what the industry wants is fish of a certain range of sizes—if such fish decrease in numbers the productivity of a fishery region is said to have decreased no matter how the smaller fish may have been affected.

The facts from several quarters now show that there may be a definite connexion between intensity of fishing, rapidity of growth, and the whole general economics of the fishery. The problem becomes, therefore, one of deciding what is the *optimum* amount of fishing that an area can stand.

No fishing at all may result in large numbers of very large breeding fish and slow growing fish of all sizes. (A heavy fishing of such a stock will naturally result in a big falling off in numbers

[1] *Ministry of Agriculture and Fisheries. Fishery Investigations*, Ser. II. Vol. VII, No. 6, 1924.

because the large ones will be caught easily and there may not be enough small fish on grounds to renew the stock.)

Real over-fishing, on the other hand, would be that which so reduced the number of egg-producing adults that the egg production came to be insufficient to keep up the stock. This has actually occurred in certain regions.

Clearly the problem of over-fishing has not become less difficult as a result of the discoveries in marine biology.

The New South Wales trawling industry comes first to the mind as a branch of the Australian fishing industry where variations in the catches are likely to be soon reflected in difficulties of finance. Now it is significant that this industry which only commenced in 1915, has recently been clamorous in its demands for Government exploration of the coast on the grounds of depletion. Putting the matter as shortly as possible—the first trawlers were able to fill up as a result of a 3 or 4 days voyage—often after 30 hours out at sea in the neighbourhood of Sydney. During the past few years the trawlers have had to steam two or more days from Sydney before starting to catch fish. The catch per unit hour, or for 100 hours fishing, has decreased notwithstanding the undoubted increased efficiency of the fishermen. Unfortunately this cannot be determined or checked by the official statistics of the fish landed in Australia. Our present official statistics allow of no deductions of any value. Owing, however, to the existence of old trawler records of the State Fishery days and the courtesy of one trawler company in making available the ships' reports for one year and in allowing one of my colleagues to make over a year's monthly voyages on their vessels, we have some other data. The total catch of Flathead landed in New South Wales for the years 1925-33 is as follows:—

1925	6,366,590 lbs.
1926	8,461,600 ,,
1927	10,763,600 ,,
1928	11,682,450 ,,
1929	15,076,676 ,,
1930	13,126,621 ,,
1931	11,421,681 ,,
1932	11,740,708 ,,
1933	9,721,495 ,,

It is impossible to say from the above whether the stock of flathead has fluctuated during the eight years, because the official statistics do not state the number of hours fishing each year or the number of trawlers engaged. Our own calculations show, however, that the catches of N.S.W. trawlers in 1919, 1921, and 1922 averaged 4·18, 4·56, and 4·68 cwts. per hour's fishing respectively. Now in 1930 the figure was only 2·97.[1]

[1] For comparison it may be stated here that from the yearly average of all boats in the Barents Sea the catch per hour's fishing is 8·9 cwts. and for Iceland waters 10·27 cwts. The highest *averages* ever made in N.S.W. waters were 6 cwts. per hour—the *Brolga* in 1922.

There is some evidence, therefore, that a diminution in the available stock of Tiger Flathead has taken place in N.S.W. waters. But not enough, judging from the possibilities outlined above, to make any assured statement possible. The fish may have migrated to new grounds. The falling off may also be the reduction which has been experienced everywhere the world over on working a new and virgin fishing ground. A new equilibrium may be set up which can remain more or less constant according to the influence of natural fluctuations.

There might on the other hand have been over-fishing. We know nothing of the fish stocks of the Australian continental shelf. As I pointed out three years ago the present New South Wales grounds only equal the area of the Irish Sea and we have removed from them in one year four times the quantity obtained from the Irish Sea in a similar time. Anyway, whilst it is now realized that natural fluctuations with rhythms often extending over periods of years are characteristic of fish stocks, and are of fundamental importance in any application of science, so is it realized that the old conceptions of an infinite fecundity of the sea are out of date. The situation discovered in our waters is important enough to indicate that statistical work is very necessary, and that it should be combined with any exploration work that may be carried out on new grounds.

Very much to be desired are more biological studies which will give us information regarding the life history and migrations of the Tiger Flathead, its breeding habits and its rate of growth. All this work involves either the use of a research vessel, or the employment of suitable workers on commercial trawlers, combined with the offer by the latter of details of their catches, which are not at present available. It should be easy by tactful agreement for the latter to be made possible especially since there should be no reason why any information obtained during this work, should be divulged or made public in any way until a year had elapsed. But the Tiger Flathead is only one example of the need for more information regarding our commercially valuable fish.

Let us now return to another aspect of our fishery research which is intimately connected with that we have just touched upon. You have seen from Text fig. 1 that some attempt has been made to apply the system of age determination by length measurements to a New South Wales fish (the Tiger Flathead).

This work was carried out by my colleague Mr. A. N. Colefax, B.Sc. (see Linn. Soc. N.S.W. Vol. 59, 1934) in connexion with a study of our most important trawled fish. A considerable amount of information was gained but unfortunately there has been no possible way of following it all up. The data provides the nucleus for future investigation. Means will have to be provided for capturing the smaller flathead. The life history of the fish between the egg and the smallest stage captured will have to be followed

The significance of the ability to recognize the age groups of fish is brought home by discoveries which may be said to rank amongst some of the most important of fishery science up to date. Both in America and Europe where elaborate statistical investigations have been carried out, it has been found that the natural fluctuations which are now recognized as highly characteristic of the fish stocks of the sea, are bound up with variations in the number of fish present belonging to some particular year group or another. For example, the application of the methods we have described has shown that in the great herring catches of any particularly good year the bulk of the fish caught belonged to a definite year group, i.e. they were all hatched years before in what was either a singularly good reproductive year or one from which an unusual number of fish had survived and developed.

Such a prevalent age group may indeed form the bulk of the valuable herring in the shoals of several successive years (see Text fig. 2). Thus the success of any particular year's herring fisheries may be entirely due to the attainment of maturity of some long antecedent very successful year of reproduction. The discovery of these facts is having two consequences.

(1) It is making it possible to forecast successful fisheries a year or even more beforehand by following the gradual growth and the attainment of commercial size of some successful year class. This forecast may eventually include the date a profitable fishing might be expected to commence, the expected quality of the catches and the estimated yield. It is the *uncertainty* and *variation* in yield in pelagic fishing which is usually most serious to both fishermen and merchants. Removal of a little of this uncertainty would be of the highest value.

(2) It has shown that one of the most important causes of fluctuation in any fish stock is due to causes which operated years before when a breeding season was a success or a failure. It has thus given us a clue to a new line of investigation.

Possibly (nay probably) the causes which determine the success of the breeding season of a species of marine fish may be always beyond our control. At present, however, we do not know what they are and it is certainly worth-while trying to find out. The most favoured assumption is that the environmental conditions prevailing during the period that the eggs are hatching out and during the immediately following weeks are of paramount importance. There is little doubt that this is one of the most hazardous periods in the life history of a marine fish and if the planktonic conditions at the time the young larva is hatched are unfavourable for it, there may be no food suitable for these delicate stages.

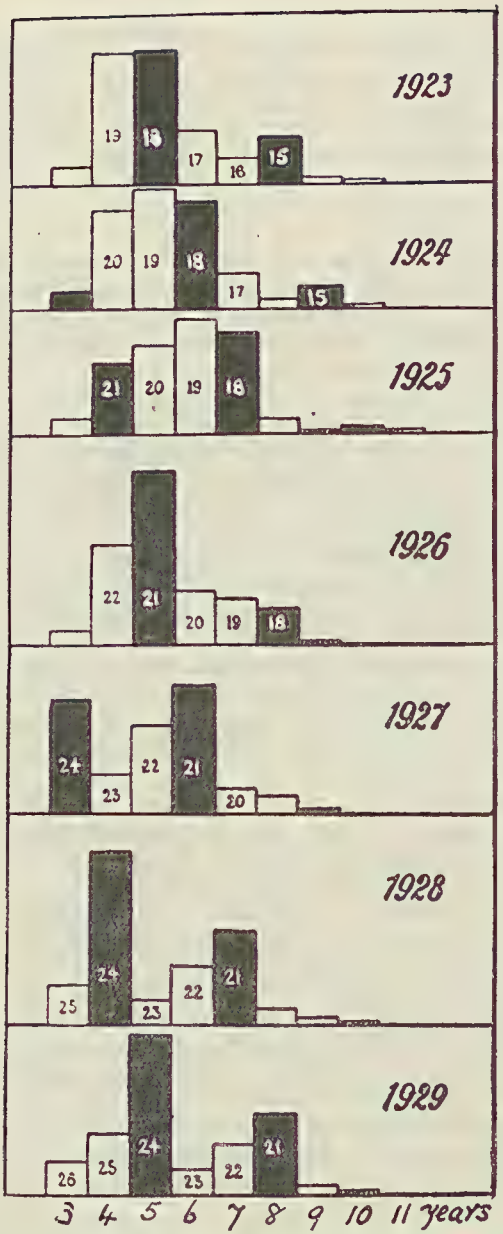

Fig. 2.—The fluctuations in the composition and abundance of herring in the East Anglian fishery from 1923 to 1929.

The figures at the bottom indicate the age of the fish in each year group. The height of the columns indicates the abundance in the catches of the particular year group, and the figure on the columns indicates year of hatching. "Black" columns represent successful year groups. (From W. G. Hodgson).

Studies of Life Histories

At the present moment we know next to nothing about the eggs or the larval stages of our Australian marine fish. There is a gap in our knowledge that must be filled up and here let me describe some of our own work in following life histories which has in its small way resulted already in a considerable success during the past few years.

The eggs of most marine fish of commercial importance are pelagic, that is to say they float in the sea. Herring eggs are exceptional, being laid on the bottom on various objects (and of course the reproductive habits of sharks and rays, fishes which sometimes come also within the purview of commercial significance, are very different from the more important teleost fishes.) In order to recognize for the first time the species of the tiny floating eggs of teleost fishes, two methods are available.

A particular fish species may be kept in numbers in ponds attached to a fish hatchery and the eggs, after extrusion from the mature females (and subsequent fertilization) may be scooped up from the water in fine silk nets, placed in hatching boxes and the development gradually followed. In this way there is no doubt at the outset that the eggs belong to the species of fish which we have in the pond. The egg may be examined and the features referred to below noted. If hatching and culture for a time are successful, the different stages from the egg until the definite adult form is reached, may all be examined and illustrated. It should then be possible on future occasions to recognize these eggs or larvae when caught at sea.

A variation of this method is to take the mature fish from a pond or aquarium tank and actually squeeze out the ripe eggs from the female and the ripe sperm from the male and conduct the fertilization in glass vessels. The whole sequence of stages can then be followed as before. This method can be easily adapted for use on board commercial fishing craft and the following simple device was invented and used successfully by us on N.S.W. trawlers. It consists of a small cylinder of celluloid with windows, these windows and the ends are covered with bolting silk. Eggs taken from mature fish captured by the trawler are introduced into the cylinder, the silk replaced and the whole thing immersed in a large bucket or other tank of sea-water which is conveniently changed or kept refilled as required. The motion of the ship keeps the submerged but floating cage, with its eggs, in constant movement, and at least the egg stages and possibly early larvae can be obtained in this way.

The main difficulty about the above methods is the obtaining of mature fish or of keeping members of both sexes until mature. Still, this is frequently accomplished, for it is the practical method of such marine fish hatcheries as are in existence.

The second method applies to the fish eggs which are captured floating in the sea water and which are taken in plankton nets sometimes in abundance, sometimes in isolated numbers.

Hints as to the possible family of fish to which the eggs belong may be obtained by reference to the known fish eggs of other parts of the world. For example, it is common in the herring group (note that although the herring lays its eggs on the sea bottom, its near relatives the sprats, pilchards, &c. have typical floating eggs), for the egg yolk to be divided up into segments. The eggs of the anchovy are oval (the yolk is also segmented here.)

Now if the planktonic fishery for eggs and larvae is continued on successive days for a period, there is a fair chance that successive stages in the life history may be captured. The following example will illustrate the method. During the months of June, July, and

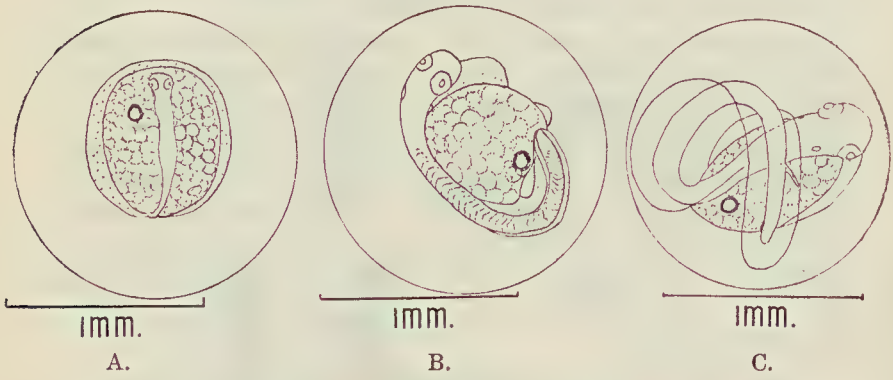

Fig. 3.—Egg of *Sardinia neopilchardus*, Steindachner, diameter 1·4 mm.

A—Early stage of development. B—Later stage of development. C—Ready for hatching. (From Dakin and Colefax.)

[Block lent by courtesy of The Trustees of the Australian Museum.]

August of the three years 1931, 1932, and 1933, numerous eggs were captured off Sydney which were characterized by a wide perivitelline space and a segmented yolk (Text fig. 3). The general resemblance suggested that the egg belonged to a member of the herring group (Clupeidae). But no less than six different species having eggs of this type were found by Delsman off Batavia. It was necessary, therefore, to have further evidence before closer identification could be made. In successive catches in each year eggs had been obtained at different stages of development and we had also taken newly hatched larvae. In 1933 partly as a result of a special effort to settle this particular question, a more concentrated search was conducted for the later and later larvae and as a result we were successful in getting stage after stage which we could link together until finally the size of 28 mm. was reached.

It was not until we had this size that we could be absolutely certain that we were dealing with the Australian pilchard (*Sardinia neopilchardus* Steindachner) but at this size the dorsal and other fins, the general form, the number of vertebrae, left no doubt of the identification. This meant, of course, that for all time we could recognize the eggs or any other early stage of this species if met with in our nets. It also meant the recognition of the breeding season and breeding grounds of the Australian pilchard, at least off the New South Wales Coast, and judging from the number of eggs present in the net, it suggested that the pilchard adults were present in large numbers. Up to the present, however, there has been practically no pelagic fishery around the Australian Coast. The herring family which probably provides the greatest sea wealth in the form of fish, remains almost untouched in Australian waters. California in 1929 took 857,000,000 lbs. of fish from the sea and of this 652,000,000 lbs. were sardines to be used for canning or for reduction purposes (oil and fish meal). The total Australian landings of fish for 1931 were only *62,969,760 lbs.* It is easy to see, therefore, why the exploration of our seas in regard to pelagic fishes is a very desirable experiment.

The search for fish eggs at sea is only part of what is known as Plankton Research. I shall return to other sides of this investigation later.

There is not very much available for purposes of comparison or recognition in fish eggs but, as Ehrenbaum points out, the size, the presence of oil globules, the character of the yolk, the shape, the perivitelline space, the colour, are all features which can be noted. In this respect preservation causes changes all round. It would be advisable to measure considerable numbers of fresh eggs of any particular type in order to determine the range of variability. In respect of the larvae—the shape, the number of the fin rays in particular, and also the number of vertebrae, are important. In addition, the colour, pigmentation, and size, should be noted.

Plankton Studies and the Life History of the Australian Peneid Prawns

There is another life history study in which our plankton work has played a part; it is published for the first time here. On various warmer parts of the Australian coast there is a valuable industry in the fishery for prawns. In New South Wales waters it has averaged about £38,000 during the last ten years. The year 1931 was, however, a peak year. The value reached £76,871 and the quantity obtained was 1,537,420 lbs. This yield is much more startling when it is realized that all this crustacean material came from river estuaries or lagoon-like lakes of relatively little depth which are open to the sea by very narrow and shallow channels (Lake Illawarra and Tuggerah Lakes) and this is in addition to heavy fish

yields from the same waters. The prawn fishery is not so important in Victoria, the annual catch being probably little more than 10,000 lbs. from the Lakes of Gippsland. Prawns of the same family are found in the Swan River at Perth but the fishery is only worth about £1200 annually. The Report of the Chief Inspector of Fisheries for Queensland for 1932-33 merely mentions prawns as scarce on the Brisbane market. They should be abundant, however, on the Queensland coast.

Now these commercial prawns of Perth, Gippsland Lakes, Queensland, and above all, of New South Wales waters belong to a Crustacean group—the Peneidae—members of which differ markedly in their mode of reproduction from those of all other groups of the Crustacean order Decapoda. It should be noted in passing that the commercial prawns and shrimps of England and Northern Europe which look superficially very similar to ours, belong to an entirely different group. The Peneid prawns are characteristic of warmer seas. They are elsewhere of commercial importance in Mediterranean countries, in the Southern United States, India, Malaya, and Japan.

Our best known species in New South Wales waters are the King prawn, *(Peneus plebejus)*, and the School prawn *(Penaeopsis macleayi)*. The former is known from Queensland down to the South Coast of New South Wales and occurs again in Western Australia. The school prawn is also known over the whole coast of New South Wales. A third species *(Penaeopsis monoceros)*, less well known on the Eastern Coast of Australia is common again in the Swan River at Perth and has a very wide range being one of the commonest of the Indian prawns and even turning up at Japan and the Philippines.

It is characteristic of our Australian crayfishes and crabs as well as of the shrimps and prawns, lobsters and crabs of Great Britain that the females carry the extruded and fertilized eggs under the abdomen until they hatch out as highly developed larvae. The Peneid life history is very different. The females shed their tiny eggs from the ovaries direct into the sea where they float during their short development until a primitive larval form—the *nauplius*—hatches out. Although this has been known to zoologists for many years it seems to have been singularly unfamiliar even to fishery experts of the countries where Peneid prawns are of commercial importance. In fact little or nothing has been said in their reports about the habits of these prawns notwithstanding the puzzle of their origin.

In New South Wales the problem of the life history of the common prawns aroused my curiosity at once—partly because I had been fortunate enough to catch the eggs and early larval stages of one species in the Swan River, W.A. many years ago. But the stimulus was great enough without this, because to many hundreds of fishermen the prawn was something of a mystery. This was the case at Lake Illawarra (and the same applied to Tuggerah

Lake and Port Jackson harbour with the Parramatta River entering it). During the winter few or no prawns can be taken with nets, and those captured are usually small. There comes a time during the spring when the king prawns become catchable in the Lakes and generally they are first taken at that end of the lake farthest away from the sea and are rather small. During the early summer larger specimens are captured, and then amazing 'outflows' or 'migrations' to the sea take place on dark nights. I have seen two or three of these 'runs' take place. Visitors at the lake entrance, young and old, take hurricane lamps or electric torches, kerosene tins, buckets and hand nets. They flock down to the entrance which connects the lake with the sea, where at low water you can stand with the outstreaming current only up to the knees. Soon there is a semicircle of closely packed people with their lights. It is now, shall we say 7.30 p.m. The water running out to sea is dark blue and clear under the lamps. There are no signs of life except for an occasional crab. The crowd waits. Suddenly someone near the lake cries out 'here they come,' and as suddenly as that, the prawns arrive. Swimming actively, the big prawns come like an army and are rapidly caught as they try to pass by until the buckets are half full and the hunters drift away homeward one by one. Fishermen with nets are at work in the lake itself. A set net at the entrance—naturally not allowed—would make an amazing capture. The moon is quite sufficient to stop the migration which ceases for a number of days at full moon unless the nights are very cloudy.

Every year this story is repeated and millions of large king prawns have been observed leaving the lakes for the sea. But no one ever saw the prawns entering the lakes or estuaries, and since the fishermen looked for eggs on the abdomen as indicative of breeding females they never found any of the latter. Knowing the life history and reproductive habits we naturally adopted the method of dissecting the large females to determine the state of maturity—but curiously enough in most cases there were only mere traces of reproductive organs. Only two theories could be put forward to explain the situation.

(1) The king prawns bred in the lakes and estuaries—this would easily explain the constant supply always moving out to sea and never coming in. But why then did the large prawns go out to sea in such definite masses? And why did one never find a really mature prawn in the lakes? Did they hide away in this condition? One would have to assume too, that the big prawns caught leaving the lake had just spawned in order to account for their small gonads.

(2) The other theory was that the king prawns bred in the ocean and never in the lakes or estuaries and that the lake supplies, enormous as they were, resulted from an early inshore migration of the young at such a small stage that they were never seen by the fishermen. On this theory the lakes would be regarded as specially favourable growing grounds where the prawns gradually increased

in size on the rich food supplies. Finally having attained large size they would leave for the sea in regular armies for their first breeding season. Our largest prawns caught in the lakes and estuaries were, according to this theory, still immature.

We set ourselves to prove one or other of these theories. Prawns were obtained from all the estuaries of New South Wales and at all seasons of the year and dissected for examination of the reproductive organs. And always (with the exception of one species to be referred to later) the reproductive organs were undeveloped. Only when we obtained a few outsized king prawns from near the entrance of Port Jackson in late summer did we find the gonads well developed. But *always* when we obtained large king prawns from the ocean (captured by trawling) the gonads were well developed (see Plate II).

At this stage in our investigation the plankton catches came to the rescue. From the beginning of March the characteristic eggs of the Peneid prawns with the developing nauplius larvae were taken out at sea in our plankton nets. Later on the young stages were also captured. And the converse is true, no eggs of the king prawns were ever taken in inshore waters. I think the life history of the school prawns is exactly the same. The breeding season of the king prawns in the ocean probably extends over at least six months for we have found king prawns at sea developing maturity as late as September.

During the later months of the year in late spring and summer the young of the prawns must stream into the estuaries and lakes, soon to take up their normal habits and grow up.

And now we come to the further surprise. The sizes of the prawns captured by us both at Lake Illawarra and elsewhere, leads indubitably to the conclusion that, with the exception of the very large ones, they are all less than a year old. The largest prawns leaving Lake Illawarra in the summer (size 18 cms.) are not less than 13 months old and no older than 18 months. Our work indicates that the king prawn breeds at about the age of 18 months and the females are then about 21 cms. in size or even more. The rapid growth and attainment of the breeding season in such a short period is not common in commercial marine products. What happens to the prawns in the sea is a very interesting question about which we know absolutely nothing. No studies on the complete life history of Peneid prawns had been made anywhere in the world until recently when the United States Bureau of Fisheries took the matter up. In a recent paper it is stated that probably their prawns never breed again after their first season. If this is the case with our Australian species it will be realised that once again pure science has information of very considerable importance in regard to the proper regulation of a valuable fishery.

I mentioned that there was one exception to the above life history. It is possible to find the adults of *Penaeopsis monoceros* with mature

reproductive organs in the inshore waters and once I found their eggs floating in the Swan River at Perth. This species breeds during the late summer months. Curiously enough they have been regarded as school prawns by most of the New South Wales prawn fishers—but school prawns which were not quite as they ought to be. In some districts they are called Greasy Backs.

The Hatching and Rearing of Marine Fish

In my introduction I pointed out that one possible way of increasing the stock of marine fish was by 'artificial' hatching—the rearing of eggs and younger stages in fish hatcheries. Is this feasible and with what possibility of success?

It is difficult to say when the first efforts in fish culture were carried out. The Romans were probably preceded by the Chinese in this respect—the fish being fresh-water fish. So far as we know, however, the eggs were laid by the fish and carefully collected by the 'nurserymen'.

In the fifteenth century (1420) a certain Dom Pinchon cultivated trout at the abbey of Reome near Montbard in France. In 1758 Lieutenant Jacobi of Hoenhausen wrote a manuscript describing how he squeezed the eggs from ripe females and the milt from the males and fertilized the eggs. Artificial fecundation was being practised by the Swiss with trout in 1772 although the function of spermatozoa was not even known at this time. Then this artificial fecundation seems to have been forgotten until it was re-discovered by a simple fisherman, Remy, of Bresse (Vosges). Remy's methods became known to the scientific world through Professor de Quatrefages in 1849. From this time on a great development of fish hatching took place, particularly in France and Germany. When the United States Fisheries Commission was instituted the possibility of counteracting depletion by hatching and rearing was visualized at the outset and such was the vigour with which this side of fisheries technology was pursued, that already in 1872 the United States had gone further almost than anyone else. Since then the United States has led the world in this matter and if one wishes to follow up the types of technique involved, reference should be made to the publications of the United States Bureau of Fisheries. There is, however, an important side of this question for our consideration. The success of fish hatching is certain in so far as it concerns fresh water fish like the carp and its relatives, the trout, the salmon and others. It is quite another matter when one regards the vast fisheries of the sea. The eggs of the trout are about as large as peas—there is an abundance of yolk, the young larvae are hardy and their early life is spent in circumscribed areas which can easily be imitated or found in other places.

One of the most dramatic successes in fish hatching was that of the introduction of the Shad from the Atlantic Coast of the United States (its natural home) to the Pacific Ocean, and its spread and

development in the waters of Canada as well as California. This, a fish of the herring family, is also a fish of the anadromous type, i.e. it spends some time in the sea but, like the salmon, leaves it and ascends rivers, to spawn in fresh water. Right at the very beginning of the American Government's attention to fishery investigation, i.e. in 1871, a consignment of shad fry was conveyed from the Atlantic coast (Hudson River) to the Sacramento River, California. This was repeated in 1873 and other years. Adult fish began to turn up within a few years and by 1876 they were getting common in the river where they had been set free. By 1895 the shad fishery of California was of extreme importance to the State and the fish had spread north to the rivers of the Canadian Coast. The species constituted the sixth largest fishery of Northern California in 1928.

This example shows what may be done in the way of introducing a fish to a new area, but it is scarcely a testimonial to the hatching of eggs of typical marine fishes. The spread of the shad in the Pacific may have been due to the occurrence of particularly favourable conditions there. Up to date even the artificial hatching of shad in the Pacific coast rivers has not been able to increase the yield sufficiently to balance human depredation or natural fluctuation.

There is singularly little evidence, then, of success in marine fish hatching. No practical results so far as I know can be put up to support the United States hatcheries for cod, although it must be noted that these are regularly continued; nothing that would be accounted beyond criticism has been put forward to support the British or Norwegian sea-fish hatcheries.

Fifty-eight years ago the United States Fisheries Commissioner said: 'Here the fish culturalist comes in with the proposition "that it is cheaper to make fish so plenty by artificial means, that every fisherman may take all he can catch, than to enforce a code of protection laws." The Salmon rivers of the Pacific slope, and the Shad rivers of the East and the Whitefish fisheries of the lakes are now so thoroughly under control by the fish culturalist that it is doubtful if anyone will venture to contradict his assertion. The question now is whether he can extend his domain to other species'.

That this was an optimistic view is evident from the fact that eight years ago the Assistant in charge of Scientific Enquiry of the United States Fish Commission said that despite 55 years of artificial propagation, the Pacific salmon fishery had declined alarmingly the shad fisheries had declined by 74 per cent. from 1896 to 1923 and the whitefish fisheries, despite an annual distribution of 409,000,000 eggs and fry, had declined in yield from first place in 1880 to fourth place in 1922. Probably in these cases, all being fish with eggs hatching in fresh waters, the results would have been worse without the aid of the culturalist.

So far as sea-fish culture is concerned the summing up by Knut Dahl in 1909 may still be said to hold good. The majority of fresh-

water fish possess relatively large and hardy eggs which are hatched resting on the bottom or glued to objects on the bottom. The period of incubation is long. The young when hatched are active, well developed, and hardy creatures. They can easily be reared, can be kept in thousands in a limited space, and fed and reared at no great cost. On the other hand the areas of the sea are so extensive that hatching operations on a tremendous scale would be necessary in order to 'be capable of influencing the enormous quantities of drifting fry which the open waters (of Northern Europe)[1] have been proved to contain.'

The pelagic eggs of marine fish contrast strikingly with those just referred to. They are small and delicate, the period of incubation in our waters may be only a day or two. And all the hatcheries can do when the young are hatched is to 'hurry these larvae into the sea where for many weeks they lead a pelagic life suspended in the waters and subject to their movements'.

I should like, however, to suggest that the last word has not been said in the matter of sea-fish hatching and I would illustrate my point by reference to a case which is almost unknown in the northern hemisphere and which has lately come under my notice in quite a new aspect.

A few months ago I visited the Pacific island of Nauru, (Australian mandated territory). The island is an old coral islet which has been raised so that its highest point is about 200 feet above sea level. In the centre is what is called the lagoon, probably a remnant of an original lagoon, but now a swampy lake cut off from the sea by high ground and very unlike the typical lagoons of coral atolls. At the time of my visit there had been little or no rain for some months. Notwithstanding this, the salinity of the water of the lagoon (which was partially dried up) was only 9 per thousand. The lagoon area is divided up into little ponds and these are crowded with a species of fish, *Chanos chanos* (known to the natives as *Ibya*). The average length of the specimens I saw caught was about 15-18 inches but they grow much larger. These fish are cultivated fish and the lagoon ponds remind one of carp ponds in Europe—highly productive areas of water.

Now the story of the Ibya fishery of Nauru is a surprising one. At a certain time of the year the natives of the lagoon district go down to the ocean coral reefs and look in the rock pools for tiny fish larvae. According to their description these little fish are only about a quarter of an inch in length and extremely difficult to see. They are fished out with a shallow strainer and placed in very ordinary receptacles in the native huts. Apparently the water is changed at intervals but the whole business is most primitive and I should

[1] The same thing will apply in other wide and unrestricted seas.

scarcely imagine that the natives understand much of what they are doing. It is almost an instinct with them. The procedure is something which has been handed down from generation to generation and probably has continued for hundreds of years on the island.

The tiny fish grow rapidly and after a few weeks when they have reached the size of about 2 cm. they are transferred to an outside pond of small size. They do not receive much further attention and gradually grow up. Two months later they are transferred to the big fish ponds of the lagoon where they gradually reach adult size and are ready when required.

Now there are several remarkable things about this business. In the first place the natives collect the larvae of a marine fish at a stage which, in sea fish hatcheries with other fish species, is set free as too difficult to handle further. In the second place, at this difficult stage they change the fish over from sea water to lagoon water which has a very different salinity and constitution. This of itself is a matter which interests me keenly because the osmotic pressure conditions existing between aquatic animals and their environments have been the subject of my researches extending over twenty years.

But let us follow this matter further. The fish (which incidentally the Europeans on Nauru have regarded as something peculiarly Nauruan) is the so-called Milk Fish, *Chanos chanos* (Forskal), (sometimes called the salmon herring), a sea fish related to the herring and of very wide distribution, ranging indeed from the Red Sea where first recorded, the Indian Ocean (on all coasts), to the Pacific Ocean (noted from the East Indies, Samoa, Society Islands, and as far south indeed as New Zealand and Australia). It often enters the fresh waters of rivers and lakes *although it only spawns in the sea.* It is an ocean fish which approaches land at the breeding season and spawns in shallow bays or on coral reef flats.

A specially interesting feature, however, is that this fish above all others is first in commercial importance in the Philippines where the people have from time immemorial cultivated it and now understand many details of the process.[1]

Actually the culture of the fish is highly characteristic of the Indo-Pacific, and is very ancient in origin. Ponds are made and used in the Hawaiian Islands, in Java, Singapore, Madura, and Formosa. But only in Nauru (and possibly at the Gilbert Islands), so far as I am aware, are the larvae cultivated in brackish water.

According to Delsman the eggs of *Chanos chanos,* (called the *Bandeng* in Java), are pelagic. The breeding fish may reach three feet or more in length and the roe contain over 5,000,000 eggs. But

[1] This, by the way, may be of great ethnological importance for it is scarcely likely that the Nauruans have discovered the culture process themselves. I should suggest that it might be evidence of the origin of the Nauruan peoples and might provide evidence that they came from Asia by the Northerly route bringing their habits with them. The early Nauruans probably recognized the fish larvae on the reef shores, having been accustomed elsewhere to looking for them.

the fish never breeds in the culture ponds. There are two spawning seasons in the year and the larvae are scooped up by men, women, and children from floating entanglements of rope set up along the shores.

No attempt seems to have been made at the Philippines (or Java) to remove the eggs from the adult fish, only the young fry are captured in the water, and this itself is a great industry for they are caught and shipped away to the fish cultivators all over Manilla. They are usually about 10 mm. long when captured and quite transparent.

At the Philippines these larvae, in numbers from 1,500 to 2,000 are placed in a 15-litre jar for transport and handled carefully. The jars are kept filled with clean sea-water. The fish larvae are first placed in a nursery pond and apparently after about two or three weeks they should be 3·0 to 3·5 cm. in length, and are then removed to the ordinary ponds. In the Philippines the larvae feed upon a blue-green algal mat (containing other microscopic plants and animals) which develops at the bottom of the pond, but I shall have to omit many of the interesting details which are known of this fish culture in the places where it is carried out.

What I want to point out is that the processes which are now organized on a big scale in the Philippines originated centuries ago as the result of someone's keen observation and experiment. This particular fish species probably lends itself to the almost domestic treatment it receives. But please note—the original Nauruans, probably trying to imitate what they or their fathers had done elsewhere before, appear to have presented it with difficulties in the nature of the salinity of the water, which are equally well surmounted by the fish. One thing is certain and that is that all the stages are able to find suitable food in plenty. One wonders whether this is not the crux of most, if not all, of the problems which have arisen in fish hatching and fish culture. Another important fact (whether dependent on the one just mentioned or not remains unknown) is the ability of the young fish to thrive in limited confining areas.

I have described this Ibya culture of Nauru because I feel that the *culture* of certain fish as well as of other marine organisms of commercial value may have to play a much more important part in the future than it has in the past. There is no branch of marine biology, however, which is more elusive—it requires patience and will probably need the full resources of the biologist and the chemist. Research of this kind should fully satisfy the pure scientist, whilst appealing equally strongly to the applied scientist. I see no reason why pearl oysters and other molluscs should not be cultivated on the northern coasts of Australia—but we know by now that rule of thumb trials can only result in waste of money—possibly biological research on an attenuated scale is not likely to be a bit better. There is of course another view, that the future will see artificial factory products supplanting the natural, (being more cheaply produced and more easily controlled) and the story of

the chemists' aniline dyes destroying the indigo industry will be repeated in the waters as in other fields. But biological science is still too far behind its sisters to say what the future has in store in its bearings on the economic production of commercially valuable living things. I have no doubt that wherever and whenever the call comes for Science to aid in this production, methods will be invented that will overcome the difficulties so far experienced.

The General Study of the Plankton

I have already indicated the importance of plankton studies in fisheries research in referring to the capture and study of fish eggs, and prawn larvae and probably in the future our plankton work at Sydney will be chiefly concerned with a search for the eggs and early stages of fish. Our first investigation, however, has naturally been a more general study of the plankton of the New South Wales coastal waters. This work has been continued over four years, and whilst in comparison with the long continued plankton researches at places in the northern hemisphere the time has been short, yet it is the first continuous investigation in the open sea of this part of the world. From the purely systematic point of view one could go on for many years making collections of plankton with varying gear and possibly getting new species—certainly new records geographically. No doubt, too, there is much physiological research of a purely scientific nature to be conducted on planktonic organisms. What interested us, however, was firstly the question whether there existed in our seas any planktonic rhythm (rhythm in production) comparable to that so much discussed in the northern hemisphere, and secondly what the degree of plankton production was in our waters. The first two years of work sufficed to show us that just as in the northern temperate regions there was a very definite rhythm in productivity with two clearly marked seasons of vigorous reproduction—the early spring and the late summer or autumn—and this was the first demonstration of such a rhythm in the *southern* hemisphere.

Now the explanation of the causes which determine the appearance of the microscopic plants and other organisms in the sea at their appointed times, their development of seasons of reproductive energy, and their disappearance or at least their reduction to smaller numbers, has not by any means been found. I have no doubt further light will be thrown on this fundamental problem of the seasons by researches in different parts of the world at different latitudes and in different environments. There is still dispute, however, as to the comparative annual productivity of the seas in plankton at different latitudes, and since this has a very decided relation to the production of the seas in fish it certainly deserves our consideration.

One of the results of that first great plankton expedition—the Kiel Expedition of the Humboldt Stiftung—was the discovery that

the catches were very many times greater in the colder northern seas than in the equatorial Atlantic waters. No doubt this was correlated with the well known northern sea fisheries of Newfoundland, the White Sea, and Iceland, and all seemed to strengthen the belief that for some reason the colder seas were more productive than tropical waters despite the converse on land (assuming that climatic conditions are at their best). A theory was indeed put forward very early by Brandt in explanation. It was based on the assumption that nitrates were the mineral substance in the sea determining its ultimate possibility in plant production, and that these were less concentrated in tropical waters owing to the action of denitrifying bacteria. Possibly there may still be room for some doubt in regard to the differential fertility of tropical seas and temperate seas respectively. There is no question, however, that during the summer months in the Antarctic seas there are enormous developments of planktonic plant-life, and that in temperate waters there are outbursts of great productivity in the springtime.

We have never obtained plankton catches off the New South Wales coast at Sydney as rich as those I used to get in the Irish Sea, and I have no doubt whatever that judged by the actual catches the average number or quantity of organisms in a litre of sea water of the Pacific off Sydney is decidedly less than that to be found in the Irish Sea. This cannot be a simple matter of latitude in its bearing on light or temperature, for there are many seawater lagoons of very great area (Lake Illawarra—80 square miles) along the coast of New South Wales in which the plankton content is high in the summer when the water temperature is as high as that of tropical seas.

It is not by any means easy, however, to determine from the observations that have been made up to date that the *actual production* or fertility of open tropical seas is less than that of open temperate seas. The rate of living is faster in the tropical waters, there is a quicker turnover and rate of reproduction. Even frequent plankton catches do not tell the story so simply as was once thought. It is only during the post-war years, as we have seen, and that notwithstanding the elaborate and costly statistical work, that scientists have realised that the presence of large quantities of big fish in an area does not necessarily mean a big production of fish flesh.

Viewed from a similar angle our quantitative plankton estimations still leave much to the imagination. We have only the most meagre information after years of work expended on far less important issues.

It seems reasonable to assume that *if* the raw materials of plant food were as freely available in the tropical seas as in other waters, the amount of annual production in live organic material would be as great in the one area as in the other—both regions would be equally fertile although a standard net catch or other type of plankton catch in the cold area might reveal more actual organic

life than one taken in tropical waters. If, for one cause or another, the raw materials of plant food were richly poured into tropical waters, production there might greatly exceed that in a cold area where such nutriment was sparse. This conception seems more likely to fit the observations which have been made. There are places in tropical waters where rich catches have been made. There are places in temperate seas where the plankton can be poor. And so far as we know, the most fertile places of the world's seas are those where a thorough mixing of the waters is constantly taking place either by reason of inflowing water from the land, or the conjunction of two ocean currents or the upwelling of water along coasts.

Quite recently I have instituted the collection of a series of plankton catches off one of the most isolated tropical oceanic islands in the world—Nauru. Thanks to the keen scientific interest of the present Administrator (Commander Garsia) catches will be attempted every three weeks for a year or more. The first catches which I made myself were moderately rich and diatoms were by no means absent. Yet Nauru is in the supposedly semi-barren tropical Pacific Ocean. Time alone will show whether this richness is due to the influence of the island on the immediately surrounding water. If, however, such is the case, Nauru ought to provide one of the best tropical stations in the world for observing this problem. The island is isolated and only about 3½ miles in diameter so that one should not expect it to exert much if any influence on the island water a few miles away from it. It is a very healthy spot with a big white population and all the amenities of life, and it rises so abruptly from the deep ocean that only two or three hundred feet from the edge of the island's narrow reef flat, the depth is 600 feet or so.

The fact is that the fertility of the sea is greatest along sea coasts and over shallow banks. It is just in such places that we already know of rich fisheries. Whether fisheries can be as rich on shallow banks in the tropics as on similar places in the colder regions seems at present very problematic, in any case practically all the intensive fishing countries which have developed the most modern fish catching machinery are in temperate zones. And I think we may say for certain that in no parts of the ocean have the great whales been found in such numbers as in the Antarctic seas. These whales—blue whales, fin whales and humpbacks—are all plankton feeders. They surely serve as testimonies to the fertility of the southern seas in high latitudes.

All this has a bearing upon research work in our own waters. I should like very much to have plankton catches from colder Tasmanian waters for comparison with those taken by us at Sydney. They would need to be taken with a view to quantitative studies. To my mind, the time has gone by for taking plankton catches

merely for the sake of listing new species or cataloguing those present.

Pelagic fish like the herring and the pilchard feed upon planktonic organisms and it has been suggested that possibly the use of plankton capturing apparatus by the skippers of drifters might help in telling them when to shoot their nets. Just as I write this, an article written by the skipper of a steam drifter comes to hand in an English fishing journal. He had been using for three years a 'Plankton Indicator' invented by Professor Hardy of Hull. The idea was that where certain species of the Copepod genus, *Calanus*, were present in large numbers, superior catches might be expected; other plankton organisms were known to be deleterious. During three months of one year the nets were shot 69 times, 40 being in water with little or no *Calanus*, and 29 in water containing 'good' or 'fairly good' *Calanus*. The average catch for the 40 in Calanus-free water was only three crans, whilst the average catch for the other 29 was 9·5 crans, an increase of 216 per cent.

Again on an occasion when the herring fishery in the North Sea made a good start the fish deserted the inshore grounds and were next located about 60 to 70 miles to the north-east, in which position they remained for the rest of the season. A research vessel found that there existed a belt of a minute and apparently deleterious plankton organism—*Phaeocystis*—extending one hundred miles east and west. There seemed little doubt that this was an obstruction to the herring.

Lastly there is another very important aspect of plankton work and that is the search to determine whether and how it may be responsible for the great fluctuations in the successful reproduction of our food fishes. There is evidence that in the 'bad years' (i.e. the years which are later on badly represented in the catches) there has been no lack of fertilized eggs produced. The 'poor vintage' may, therefore, be due to these eggs meeting unhealthy physical and chemical conditions in the sea, or maybe the newly hatched young find only a poor development of plankton of the right kind when this is so very essential as food material.

Conclusion

I trust my remarks tonight have been sufficient to show that a branch of zoology which may definitely be called Fisheries Science is gradually developing. The progress has been slow. For many years the proper relation of its subdivisions was not realized and certainly those engaged had little notion of the underlying complexities. Many investigators were too well satisfied with their intriguing little problems in marine biology to consider whether their application to fishery problems was obvious enough to balance the expenditure of time and money upon them. And so far as England was concerned, and possibly this is equally true of the

United States, any brilliant investigators in marine zoology probably looked ahead for positions which were not to be found under fishery committees—their association with fishery problems was thus temporary and continuity of research was lacking. This criticism, however, does not apply so much to the Germans and Scandinavians. Times have changed now and the work of the immediate future should be particularly interesting.

Not so very many years ago the opinion was frequently expressed that the yield of the sea was infinite. Did not the females of certain fish species produce 7,000,000 eggs in one spawning season! A simple view, for it is clearly as necessary for such a species to produce its 7,000,000 eggs if the stock is to remain *constant* as it is for the whale to produce its single young each year or the shark its twenty or thirty.

The highly efficient engines of modern fisheries have induced other ideas and from all over the world come stories of fish depletion. I have indicated some in the above account. Let me conclude by referring to another from a country near to us—New Zealand.

Mr. A. E. Hefford, the Chief Inspector of New Zealand Fisheries, in his Report of 1929, was particularly to the point when he said that the

'all important consideration for fishery Administration and for the fishing industry is as to how far the reduction of a stock of fish can proceed before the condition which can be termed positive depletion, has been reached . . .

'And especially we must recognise that there is no reason to think that New Zealand Fisheries may be developed to the same degree as those of Europe or North America. *There is no indication of anything approaching the same extent of fishery resources as those of the Northern Hemisphere. There is all the more reason, therefore, for studying what assets we have, with a view to their most economical exploitation'.* (Italics mine).

This is an interesting expression in view of the prevalent opinion in Australia as to the richness of New Zealand waters.

The fundamental problem facing the science of Sea Fisheries is everywhere the same—the valuation of the fishery stocks and the determination of what is going on when man adds his attack to the fluctuations of nature.

I am not going to suggest for a moment that Australia should institute anything on the extensive lines followed by the United States of America, Japan or England. Far from it. I am not at all convinced yet of the supposed enormous richness of our fishery resources. Why should I be in view of the lack of what I call real knowledge. I regard as pure blague the statement that Australia has the greatest fishing coast in the world. Time enough to make comparisons when we know more about it.

It is essential, however, that we should do something, and in a manner that will ensure that what is necessary is done in the most economical way. This implies that it must be efficiently carried out and by people thoroughly qualified to do the work. There is only one body in Australia that is in a position to regard the scientific work in the proper perspective and that is the Commonwealth Council for Scientific and Industrial Research. In their hands I can leave it.

Although it is not altogether to be placed under the head of scientific research, I am quite of the opinion that under the conditions peculiar to Australia, the Government might well undertake to help in the discovery of new fishing grounds and the investigation of the best fishing gear for use on them. The seas are open to all and the industry should benefit many beyond those directly engaged in fishing.

At the present time most of our trawlers are unable to explore beyond the 100-fathom line, although some of the most useful fishing in the world is now carried out at twice that depth. There are now French trawlers with refrigeration plant and storage for 700 to 800 tons of frozen fish, retorts for cooking lobsters, plant for the reduction of fish into oil and scrap, and storage tanks for 26,000 gallons of oil. Trawlers of this kind will travel across the Atlantic to their fishing grounds and remain away for weeks at a time.

The vast field of the pelagic fishes so intensely valuable to other countries has been left altogether unexplored commercially around Australia. The pilchard was worth 3,587,464 dollars to California in 1929, the value of the herring alone landed in Great Britain in one year may be over £5,000,000. How can these pelagic fish be caught best in our waters? Will the drift net, the purse seine, the lampara or other devices prevail? The problem entails a big experiment—it is not exactly one for a private company or individual since the results are for the many. There will be no exclusive licenses.

The Commonwealth Government has now agreed to make these explorations for pelagic fish and in making that decision I think it has done well. Let us not make the mistake of missing the opportunity for conducting statistical and other pure fishery research when these experimental explorations are made. It is cheaper to investigate resources in advance rather than after depletion has taken place.

One of the greatest dangers that Science faces today is that of being expected to produce some great discovery to order, which will bring considerable wealth for an extremely low expenditure. It has been well said that the average individual's interest in science is the hope of getting something for nothing. I regret to say that some of the most sanguine promises have been made to the fishing industry.

I see no reason why scientists should promise the fishing industry easy money. Their work is rather to be regarded as essential to the people for the proper conservation and the utilisation of nature's

products. To the fishery industry it might be regarded at least as an insurance although it might turn out a most profitable investment.

I have no doubt that explorations at sea and tests of new fishing gear will show up new grounds and may improve the catching power of the appliances used. This, however, is relatively simple work, involving fishing technique rather than the finer studies of science.

But all this work without the institution of better methods of transportation and marketing would result in worsening the present economic conditions in the industry instead of bettering them. I do not think I can agree with the view that the lack of scientific research up to date has been responsible for the slow development of the Australian fishing industry. There are many other causes. The so-called fresh fish as received by the Australian housewife is, in most localities, a burlesque of the real thing.

The help of the scientist in the development of up-to-date and really modern canning industries, refrigeration methods, the utilization of waste products, the preservation of fishing nets, the propagation of shell-fish, the toxicity of paints and poisons to marine growths, and in the solution of a large number of other problems, is of course, obvious to most.

The use of plankton studies, the study of life histories, of fish eggs, the study of the prevailing hydrographic conditions in the sea and the expenditure of money on the statistical analyses of our fish stocks, are not so obvious. Such researches might result in new culture methods, they might help to discover the secret of the curious fluctuations in the riches of the sea and to make forecasts of the fisheries possible. They will certainly help to an understanding of the conditions upon which fishery legislation must be based, for to have Fishery Acts and Regulations without knowledge cannot be sufficiently condemned.

Unfortunately, so long as neither fishermen nor those who govern us are ever told or instructed as to the reasons why much of the scientific work is conducted, it will never be found possible to enlist the help and sympathy which are so essential to success.

There have been, during the past few years, many cries in the newspapers for Government help in connexion with fisheries. Perhaps if those making most noise had been really altruistically concerned about the general advance of the fishing industry of Australia, something more might have been achieved than the state reached at present.

Unfortunately most of the reproaches have come from interested company promoters whose one idea of Government help was the obtaining of money grants in order to float new concerns, the future of which might be left to unhappy shareholders. This would be a disastrous waste of money and quite against all the advice of the numerous witnesses and experts who attended the meetings of the Commonwealth Fisheries Conference during the years 1927-9.

The only reason the promoters of the projects referred to above have applied to the Governments is because they have met with little response from the investing public. The investing public have probably refrained because they realized that the projects were based on incomplete data.

There are plenty of bonafide fishermen all round the Australian coast and no doubt many business men of standing who would enter into or extend the fishing trade if *shown* that *constant supplies* of fish were available in the sea and markets were forthcoming for their products. To explore every possible line of enquiry might well be regarded as the duty of a Government; to hand over money to any 'Tom, Dick and Harry' is something which John Citizen would be the first to criticize.

Some years ago a British official from India visited Japan in order to study its fishery methods. In his report he noted that much of the Japanese success was due to the 'Co-operation of Government and people: The Government statesmanlike, resolute in progress on lines systematically thought out and determined, imbued with the scientific spirit, liberal in the necessary expenditure; the people responsible, enterprising, alert to utilise opportunity and to follow example'.

I should like to stress that attitude and to remind you, in conclusion, that it is from a flourishing fishing industry that the great maritime nations have recruited some of the best and most desirable men for the merchant service and the navy.

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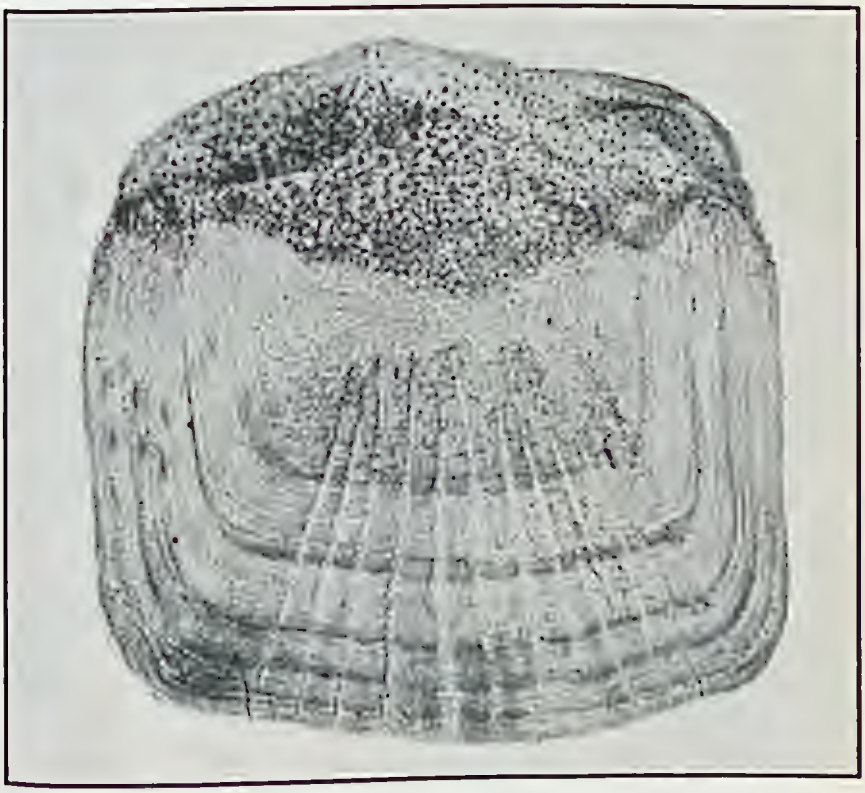
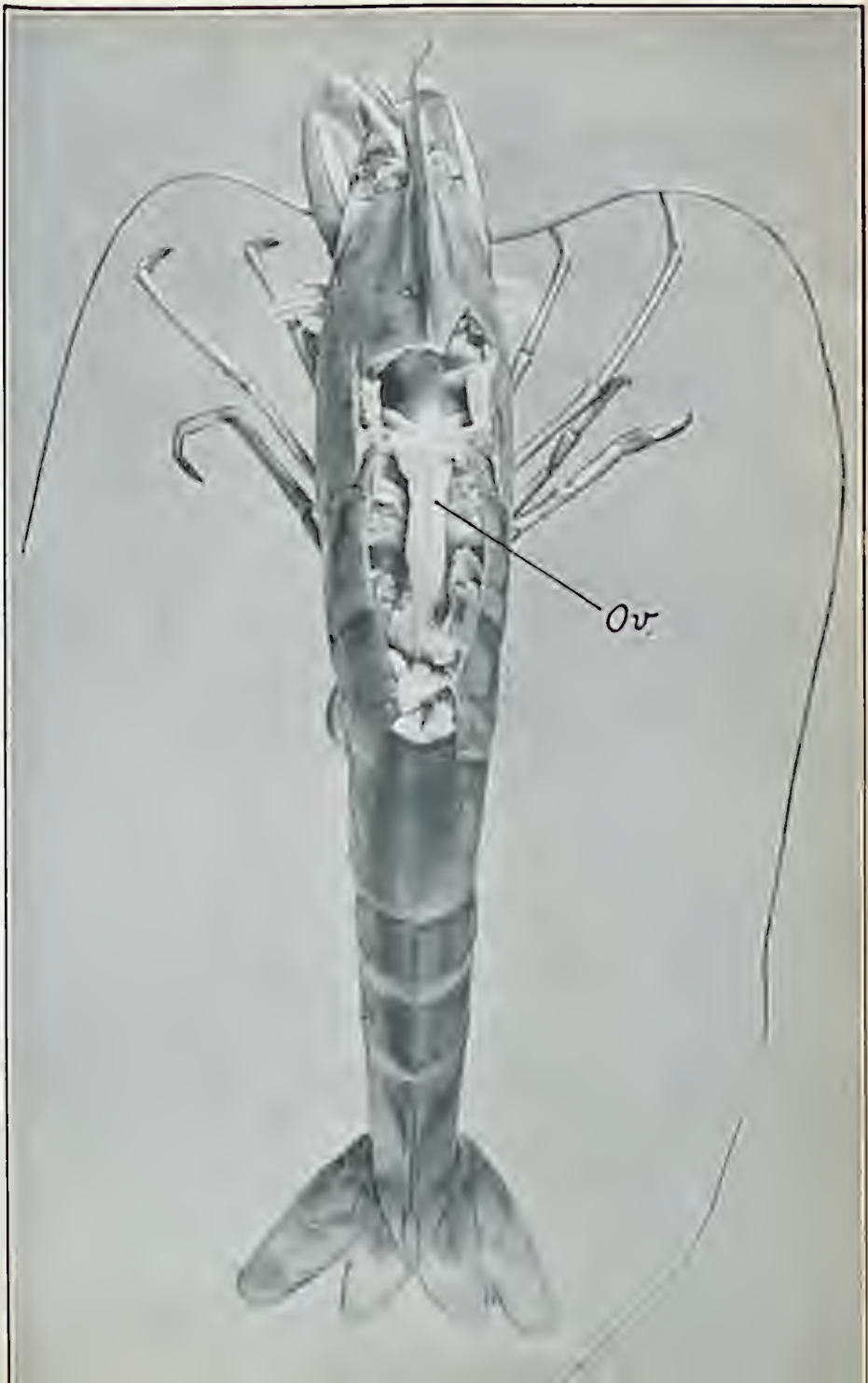
EXPLANATION OF PLATES

PLATE I.—Scale of Tasmanian Trumpeter (low magnification).

PLATE II.—King Prawn *(Peneus plebejus),* female, almost mature, showing ovaries (ov.).



Scale of Tasmanian Trumpeter. (Low magnification).


Ov.

rays. Snout 3·8 [3·7–4·1] in head; eye 4·2 [3·7–4·6] in same, or 1·1 [1·0–1·2] in snout, or 1·1 [1·0–1·3] in interorbital width.

Teeth. Biserial in both jaws: arranged in each premaxilla (Text fig. 1A) and each ramus of the mandible (Text fig. 1C) in an outer series of about 20, subequal, subconical, bluntly pointed, somewhat recurved, averaging one to one and a half times as long as their interspaces; and in an inner series of about 14, directed inwards and slightly upwards, larger, more compressed, more sharply pointed

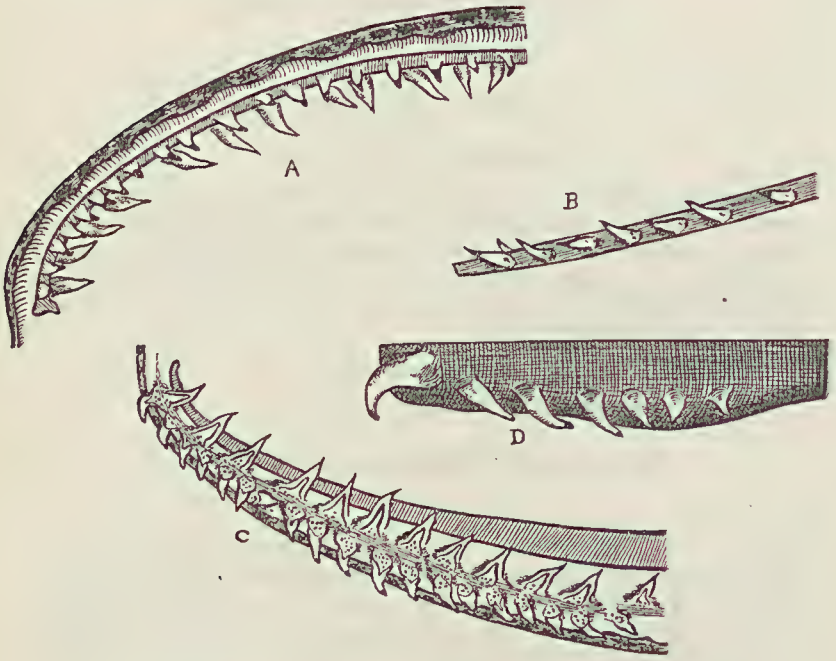


Fig. 1.—*Paragalaxias shannonensis*, sp. nov. Teeth enlarged.
A.—premaxillary. B.—entopterygoid. C.—mandibular. D.—lingual.

than those of the outer series, their interspaces about equal to, or less than, their length. On each entopterygoid (Text fig. 1B) a single series of about 8, fairly comparable with those of the inner series in the jaws, their interspaces, which progressively increase backwards, averaging rather more than their length. On the tongue (Text fig. 1D) two lateral series, each of 6–8, diverging posteriorly, the anterior pair, which are almost or quite contiguous basally, usually the largest, three to four times as large as those of the outer series in the jaws, bluntly pointed, much recurved.

Nostrils and Mucus-pits (Text fig. 2). Nostrils large, the anterior nearer to tip of snout than to orbit, the posterior about twice as

far from anterior as from orbit. Mucus-pits most evident on dorsal surface of head, where there are six, relatively very large.

Dorsal fin. Large; fourteen [fourteen–fifteen] rays, thus, II + 11 + I [II–III + 11 + I]: in several of the smaller paratypes all rays remain unbranched, their stems quite uncleft, and the pencillate extremities that characterise all rays and ray-branches scarcely, or not, distinguishable into two tufts. Originates virtually above base of ventral, being behind level of latter by 1·4% [0·9%–1·4%] of total length without caudal: distance from its origin to base of caudal 2·7 [2·5–2·7] in total length, or 2·2 [2·2–2·3] in length without caudal. Its largest, 5th [5th or 4th], ray with its membrane 1·8 [1·6–2·1] in the head; its base 1·4 [1·1–1·5] in the same, or 1·3 [1·0–1·5] in its distance from caudal. Laid back, reaches level of base [base-middle] of last anal ray laid back, its total horizontal extension being between one-third and one-fourth total length without caudal.

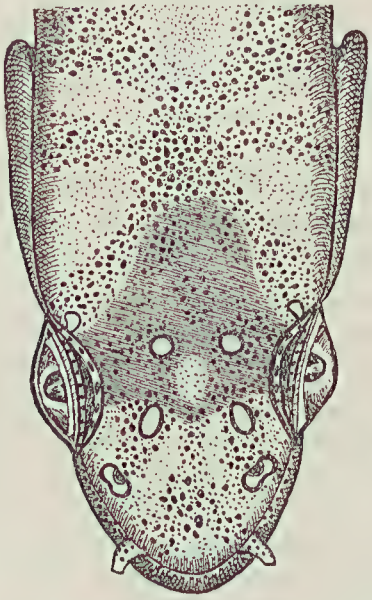


Fig. 2.—*Paragalaxias shannonensis*, sp. nov. Dorsal aspect of head, showing anterior and posterior nostril, and mucus-pits; enlarged.

Anal fin. Moderate; nine rays, thus, II + 6 + I [II + 6 + I]: in several of the smaller paratypes all rays remain unbranched, as in dorsal. Originates below 12th [11th–12th] dorsal ray. Its longest, 4th [4th or 5th], ray with its membrane 2·1 [2·0–2·4] in the head; its base 2·7 [2·3–2·7] in the same, or 1·8 [1·5–1·8] in its

distance from caudal. Laid back, virtually reaches caudal ridge [usually fails to do so by ½–⅔ length of its last ray].

Pectoral fins. Large, distinctly pedunculated; 12 [11–13]; extending 0·8 [0·7–0·9] of the distance from their origin to origin of ventrals.

Ventrals. Six-rayed, thus, I + 4 + I [I + 4 + I]; originating very slightly in advance of dorsal, at a point about equidistant from anterior margin of eye and base of caudal; extending 0·8 [0·7–0·9] of the distance from their origin to origin of anal.

Caudal fin. $13 + \frac{c.\ \text{IX}}{c.\ \text{XI}} \left[12\text{–}13 + \frac{c\ \text{VIII–XI}}{c.\ \text{VIII–XI}} \right]$; its length 5·9 [6·1–6·4] in total length; emargination-index 2·4 [2·3].

Caudal peduncle. 2·3 [2·1–2·4] times as long as deep; its length 0·6 [0·5–0·6] in postorbital portion of head.

Life-Colours. General colour translucent greenish, blotched or barred with greenish brown. The pattern varies considerably, but characteristically, as in the holotype, consists of 10–12 large blotches tending to form subvertical bars, from once to twice as wide as their interspaces, in linear series along the side, and of similar blotches, sometimes forming well-marked saddles, on the back. No special scapular bar. Under surface paler than sides and back, minutely punctuated with darker behind vent, and usually also, though more lightly, in a narrow cross-zone near level of base of pectorals. Head in general concolorous with body; a dark blotch near occiput; no dark streak beneath eye. Iris golden, heavily spotted, especially superiorly, with blackish; pupil blackish. Operculum with briliant metallic green-gold blotch. Fins pale, immaculate (macroscopically), often with distinct greenish tinge basally. Through the transparent body-wall the enteric canal shows metallic greenish gold, and the vertebral column is seen to arch slightly over the silver air-bladder, which is embraced by about 10 pairs of ribs, while the dorsal aorta and its backward extension as the caudal artery are traceable as a dark blue, almost black, line.

Under a lens the body exhibits numerous black chromatophores, subcircular or stellate, the latter type much resembling those of *Galaxias attenuatus*, and chiefly constituting the body-bars; there are also scattered small subcircular orange spots. In all fins rays are white, with, occasionally, some orange spots near the base, these being few except on the caudal, where they extend thickly over the proximal two-thirds, or more, of the ray; rays with a row of black chromatophores along either border. Membrane in all fins mainly white, sometimes somewhat greenish basally, with scattered orange and black spots, much more abundant and conspicuous on caudal than on any other fin.

Material Examined. Described from the holotype (figured), seven paratypes, and paratypic microscopical preparations (from which teeth are figured). Holotype (Regd. No. HT939a), a paratype (Regd.

No. PT939b), and slides of paratypic material (Regd. Nos. PT. sl. 939c-n) in the collection of the Queen Victoria Museum, Launceston, Tasmania. Paratypes will be offered to the British Museum (Natural History), London; Australian Institute of Anatomy, Canberra; Australian Museum, Sydney; National Museum, Melbourne; Tasmanian Museum, Hobart; and Museum of the Biology Department, University of Tasmania, Hobart.

Locality. Shannon River, Tasmania. Three specimens collected on 3rd December, 1933, remainder (about a score) between 29th March and 2nd April, 1934: all from two small beds of water-weed (*Potamogeton* sp.), one situated about two or three yards, the other about forty yards, below the road-bridge over the Shannon between the Great Lake hydro-electric dam at Miena and the Shannon Lagoon. Secured with a hand-net (a method by which, in my experience, members of the genus *Galaxias* are very rarely obtained), along with half a dozen two-four inch specimens of *Salmo irideus* Gibbons.

As pointed out by Tillyard (1933), this stretch of fast-running water, about half a mile in length, has a well-marked ecological character. It is famous among anglers for its phenomenal rises of the so-called Shannon Moth, a handsome undescribed snowflake-caddis of the genus *Smicridea*, on which the introduced Salmonidae feed voraciously.

Remarks. The presence of ventral fins and of teeth on the entopterygoid, and in addition the general appearance and habits indicate a closer affinity with *Galaxias* than with *Neochanna*.

Except for *Galaxias dissimilis* Regan (1906), believed to be from New South Wales, and *G. cleaveri* Scott (1934), from Tasmania, each of which rests on a single specimen, the present is the only known Australian member of the family with six-rayed ventrals.

The anomalous *G. dissimilis*, for the reception of which the traditional concept of *Galaxias* as a genus with the dorsal in a markedly posterior position had to be modified, has long been a puzzle. McCulloch (1921, p. 28) went so far as to suggest that 'The unique holotype of this species is perhaps merely an abnormal specimen'; while Whitley (1933) in making available the first figure (Pl. XII, Fig. 2), a sketch by Regan, remarked (p. 61) that it 'may not be congeneric with' a species of *Galaxias (G. o'connori)* just discussed. The present form may perhaps shed light on this long-standing problem, as a comparison of its characters, apart from the dentition, with those of *G. dissimilis*, as described and figured, suggest the two are probably congeneric.

Should a re-examination of the dentition of *Galaxias dissimilis* show that this species should enter the present genus, it would be distinguishable from *P. shannonensis* by, among others, the following characters:—snout in *dissimilis* 'much longer than eye,' in *shannonensis* subequal to eye; maxillary extending in *dissimilis* to below anterior ¼ of eye, in *shannonensis* not so far as, or just to, level of anterior margin of eye; one to two more dorsal rays in

shannonensis than in *dissimilis*; caudal *peduncle* in *dissimilis* $1\frac{2}{3}$ as long as deep, in *shannonensis* more than twice (average, 2·2 times) as long as deep.

The collection of the greater part of the material here dealt with has been made possible by the granting by the University of Tasmania of a research scholarship for an investigation of the Tasmanian Galaxiidae: grateful acknowledgment is made of this assistance, also of permission to submit the present paper, as a separate section of the report, to this Society. To Mr. V. V. Hickman, B.Sc., B.A., Ralston Lecturer in Biology, in whose Department the administration of the grant lay, thanks are tendered for much kind encouragement and assistance.

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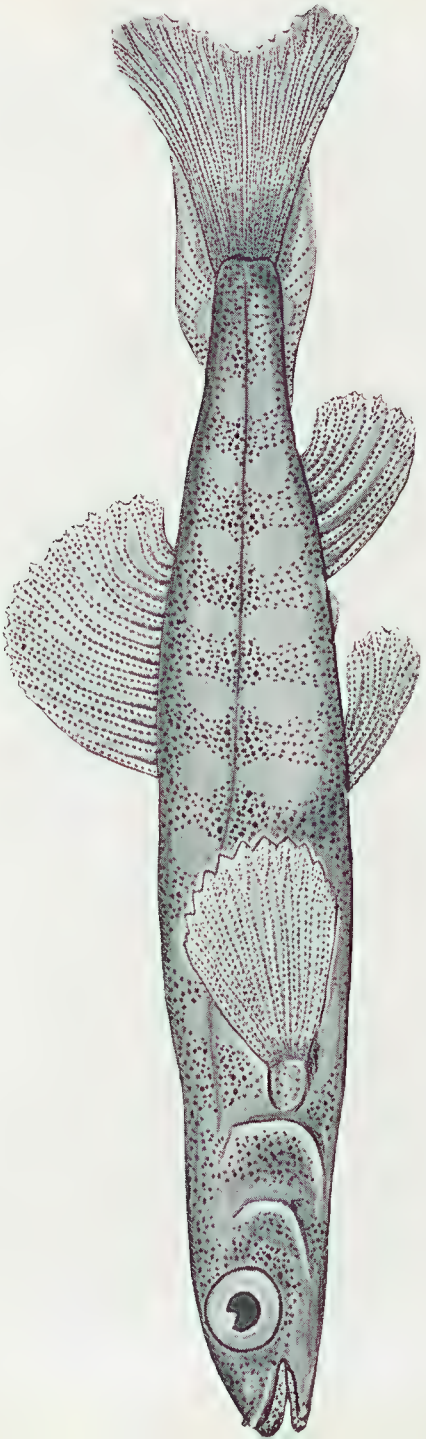
Explanation of Plate

Plate III.—*Paragalaxias shannonensis*, sp. nov. Holotype. Locality, Shannon River, Tasmania. Total length 40·7 mm.



Paragalaxias shannonensis, sp. nov. [E.O.G.S. del.]

29.APR.1925
VICTORIA

Notes on the Gobies Recorded from Tasmania, With Description of a New Genus

By

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One Plate and Two Text Figures

(Read 26th September, 1934)

Four species of Gobiidae have at various times been accredited to Tasmania. It cannot be said, however, that our knowledge of the members of the family occurring in our waters at present rests on a very satisfactory footing. In the present paper, the more precise scope and conclusions of which are summarized in the concluding paragraph, some notes on the recorded forms are given, and a new genus is described.

Registration numbers are those of the Queen Victoria Museum, Launceston.

Family Gobiidae

Genus **Nesogobius** Whitley, 1929

Nesogobius hinsbyi (McCulloch and Ogilby)

Gobius pictus Castelnau, *Proc. Zool. Soc. Vict.* I. 1872. p. 124: preoccupied by *G. pictus*, Malm, 1865. *Id.* Macleay, *Proc. Linn. Soc. N.S.W.* V. 1881. p. 599.
Gobius hinsybi Johnston. *Pap. Proc. Roy. Soc. Tas.* 1902 (1903). Abstract. p. 10 : *nomen nudum*. *Id. Waite, Rec. S. Aust. Mus.* II. 1. 1921. p. 146. fig. 229. *Id.* Lord, *Pap. Proc. Roy. Soc. Tas.* 1922 (1923). p. 70. *Id.* Lord and Scott, *Synop. Vert. Anim. Tas.* 1924. pp. 73 and 82.
(Gobius) hinsbyi McCulloch and Ogilby, *Rec. Aust. Mus.* XII. 10. 1919. p. 215. pl. XXXIII. fig. 1: *ex* Johnston MS.
Nesogobius hinsbyi Whitey, *Pap. Proc. Roy. Soc. Tas.* 1928 (1929). p. 62. *Id.* McCulloch, *Aust. Mus. Mem.* V. III. 1929. p. 369.

Locality. McCulloch and Ogilby's Tasmanian specimens came from Wedge Bay, Tasman's Peninsula. I find the species is abundant in pools between tide-marks at Burnie, and West Ulverstone, N.W. Coast.

Life-Colours. The following notes on the colours during life were made from a specimen, 54 mm. in total length, obtained by the writer at Burnie, on 7th August, 1934 (Reg. No. 942a).

General colour above sandy, made up of greyish white dotted and reticulated with golden-brown. Six narrow bars of olivaceous brown on back, the first, which is interrupted mesially, just behind level of preopercular margin, second at level of opercular margin, third near middle of first dorsal, fourth near middle of second dorsal,

fifth behind level of second dorsal, reached by that fin laid back, sixth just in advance of origin of caudal ridge: except the first and second, these bands extend down to about midlateral line, uninterruptedly in last two, interrupted by a forward displacement of the lateral element in others. Sides concolorous with back down to midlateral line, where they pass, rather sharply, into white, which continues over the whole ventral surface: along line of demarcation a greyish band, formed by blackish punctulations, which is best-marked and widest below spinous dorsal. Seven moderate sized, dark brown, almost black blotches along midlateral line, extending half into upper sandy, and half into lower white region; the first elongated vertically; first three covered by adpressed pectoral; last, at base of caudal, Y-shaped with the azygous limb directed forward. From midlateral line to ventral profile run about a dozen very narrow subvertical pale golden brown bars, somewhat irregularly spaced, and scarcely extending behind level of termination of soft dorsal.

Head in general concolorous with body. Behind eyes a dark indeterminate transverse bar, subcontinuous with a sharply defined, almost black bar on operculum, immediately behind, and following outline of, posterior margin of preoperculum; a blackish streak from eye towards angle of mouth; a short black subvertical streak below, but not reaching to, anterior portion of eye. Iris in general greyish brown, freckled with darker brown; pupil narrowly ringed with shining golden orange.

Dorsals with colourless membranes, bearing punctulations that give rise to pale brownish regions forming three or four arcs, the narrower interspaces whitish; these markings rather more conspicuous on first dorsal. Posterior margin of first dorsal with a conspicuous broad white marginal band. Pectorals and anal almost colourless, lightly barred with fawn. Ventrals colourless distally, thickly spotted with opaque pearly white proximally: the general appearance of the fins is beautifully white, tinged in parts with fawn, and exceedingly delicate and feathery.

Variation. As pointed out by McCulloch and Ogilby (1919, p. 216), there is considerable variation in colour-marking. A series of nine specimens (Reg. Nos. 942 a-i) yields the following notes. Narrow transverse bars present only in largest specimen; five specimens with white spot on occiput; three with white spot on superior border of pectoral base; three with white markings on cheek and operculum; seven with white mid-dorsal spot near origin of first dorsal, and a less conspicuous one near origin of second dorsal; opercular stripe scarcely developed in smaller individuals; dorsal cross-bars very variable in width and intensity; five to seven dark blotches along midlateral line, rather variable in extent and intensity, usually squarish, except the one at caudal base, which is either Y-shaped, or else composed of an anterior blotch and an adjacent or confluent vertically elongated stripe, often the darkest

element of the whole series; occasionally small spots, perhaps representing incipient vertical bars, between, and slightly below, the main lateral blotches.

The principal proportions of these nine specimens—the largest, 54 mm. in total length, from Burnie, the remainder, 26·2 mm.–46 mm. in total length, from West Ulverstone and near Goat Island—are noted below for comparison with those of the 86 mm. specimen from Wedge Bay, described by Ogilby and McCulloch. Depth before ventrals 4·6–5·8 in length to hypural joint; head 3·1–3·7 in same. Eye 3·4–4·1 in head, and 0·8–1·3 in snout, which is 2·9–4·1 in head. Depth of caudal peduncle 3·5–4·3 in head. Breadth before pectorals 0·96–1·12 in depth there.

None of my specimens has more than seven spines in first dorsal, but, it is of special interest to note, two have six only. D. VII, 9 in six specimens; VII, 10 in one; and VI, 9 in two. A. I, 8 in eight specimens; I, 9 in one. P. 18-20. V. I. 5. C. 13 + $\frac{c.\ 4 - 10.}{c.\ 4 - 11.}$

Habits. This attractive species is tolerably common in pools between tide-marks at Ulverstone and Burnie, and I have observed what is apparently the same form in great numbers along a shallow sandy bank of the River Leven, about a mile inland. It is very swift moving, and when disturbed darts away with celerity, either to the shelter of a rock, or, remaining in the open, coming to a halt after a yard or two, and resting on the sand, into which it often buries itself to the depth of the midlateral line, the white lower half of the body thus becoming entirely hidden, while the exposed half, with its delicate mottlings of grey and golden brown, harmonizes admirably with the surrounding sand. When at rest, or when disturbed while in a vessel, it not unfrequently completely lowers the dorsals, so that they become scarcely discernible. Though decidedly shy, it is at times captured with little difficulty by sliding a flat stone beneath the sand on which it is resting, and flicking it bodily into a waiting net. It appears to show a marked preference for pools whose bottoms are wholly or partly sandy, and I have found it in general useless to seek it in those of a purely rocky character.

Remarks. The following additions may be made to the excellent description by Ogilby and McCulloch. B. 6. Gill-rakers on lower limb of anterior arch about 6, mamilliform. The double series of mucigerous papillae running towards the angle of the mouth is subcontinuous with a double series on the inner mandibular margin. On the caudal there occurs a series of pore-disks: this regularly comprises a mesial row, present on either surface of the membrane, running from near caudal base to, or almost to, posterior margin of the fin, and commonly includes also one or two shorter, less regularly constituted lateral rows, of which the lower is the more constantly present.

Synonymy. McCulloch and Ogilby with little hesitation relegate to this species *Gobius pictus* Castelnau (not of Malm). As Castelnau's species, from St. Kilda, Melbourne, has not hitherto otherwise been recognized, the suggested synonymy is probably correct. At the same time, however, since Whitley (1929, p. 62) has assessed the presence of more than six dorsal spines—a feature on which McCulloch and Ogilby laid considerable emphasis in advocating this identification—as a character of generic value, it is worth recalling, as a memorandum for future investigation, that Castelnau's description includes some points—*e.g.*, lower jaw projecting, second dorsal spine lower than the others—not readily compatible with the present species.

Genus **Arenigobius** Whitley, 1930

Arenigobius tamarensis (Johnston)

(Plate IV, fig. 1)

Gobius tamarensis Johnston. *Pap. Proc. Roy. Soc. Tas.* 1882 (1883). p. 120. *Id.* Macleay, *Proc. Linn. Soc. N.S.W.* IX. 1. 1884. p. 32. *Id.* Johnston, *Pap. Proc. Roy. Soc. Tas.* 1890 (1891). p. 33. *Id.* Lord, *Pap. Proc. Roy. Soc. Tas.* 1922 (1923). p. 70. *Id.* Lord and Scott, *Synop. Vert. Anim. Tas.* 1924. pp. 13 and 81. *Id.* Whitley, *Pap. Proc. Roy. Soc. Tas.* 1928 (1929). p. 61. *Id.* McCulloch, *Aust. Mus. Mem.* V. III. 1929. p. 370.
(Gobius) tamarensis McCulloch and Ogilby, *Rec. Aust. Mus.* XII. 10. 1919. p. 229.
Gobius lateralis ? Lord and Scott, *Synop. Vert. Anim. Tas.* 1924. p. 81.
Gobius tasmanicus Whitley, *Pap. Roy. Soc. Tas.* 1928 (1929). p. 62: *ex* Johnston MS.

Historical Note. Johnston's original description of his *Gobius tamarensis* is a brief one, occupying some twenty lines in his catalogue. So far as I am aware, the species has not been recognized since Johnston's time; and accordingly a redescription and figure are here offered. A discussion of the synonymy outlined above is conveniently postponed till the species has been described, and hence appears under a separate heading below.

Description. B. 5. D. VI, 9. A, I, 8. P. 18-20. V. I, 5. C. 13 + $\frac{c\ 2-5}{c.\ 2-5}$. Scales between axilla and hypural joint, 32–33, and between anterior dorsal and anal rays 11–12. Gill-rakers on lower limb of anterior arch about 7, stout, elongated, cylindro-conical.

Greatest depth 6·4–7·3 in total length; depth at level of pectoral base 1·1 in breadth there, and 5·6–6·4 in length to hypural joint. Head 3·4–3·7 in length to hypural. Eye 1·2–1·3 in snout, which is 3·8–4·0 in head. Interorbital width 2·4–2·8 in eye. Depth of caudal peduncle 2·0–2·8 in its own length, and 2·7–3·4 in head.

Head entirely naked; moderately depressed, its depth 1·1–1·4 in its greatest breadth, and 1·0–1·3 in breadth at level of hinder orbital margin. Cheek and opercles with rows of mucigerous pores, arranged as shown (Plate IV, fig. 1). Open pores present in rows along

nuchal grooves; several scattered rostral pores, and an interorbital one. Snout convex, obtusely conical. Anterior nostril in a short tube, about thrice as far from eye as from margin of preorbital; posterior nostril in a scarcely developed tube, about midway between anterior nostril and orbit. Eyes moderate, cutting the dorsal profile. Interorbital space slightly concave. Mouth oblique; jaws subequal anteriorly, or lower distinctly projecting; maxilla extending to below middle, or, exceptionally, posterior third, of eye. No barbels or cirri. Anterior premaxillary teeth in four rows; the outer three rows villiform, but exhibiting some gradation in size, on the whole 3rd > 2nd > 1st row; inner row large, acute, tending to increase in size backwards: behind the middle of the jaw, reduced to two or three rows, those of the outer row, or rows, larger than they are anteriorly, and two or three teeth of the inner row, just behind the middle of the jaw, caniniform, inwardly curved. Palate toothless. Mandibular teeth in about five rows anteriorly, decreasing, by loss or confusion among the middle rows, to three or four posteriorly; outer row cardiform, increasing somewhat in size posteriorly; next three rows villiform, more closely spaced than first row; inner row large, acute, inwardly curved, increasing in size backwardly to about the middle of the series, where there are two or three markedly caniniform. Tongue broad; its posterior half adnate to floor of mouth; its free anterior margin shallowly, somewhat broadly notched. Gill-openings chiefly lateral, a little wider than the isthmus, the breadth of the latter more than length of snout. Exposed edge of shoulder-girdle smooth.

Body fairly robust, subcylindrical anteriorly, compressed posteriorly. Covered with ctenoid scales; angular and rather large posteriorly, where they extend for one or two rows, especially laterally, on to the caudal base, more rounded and smaller anteriorly, where they cease, on the dorsal surface, at about the level of the hinder edge of the pectoral base mesially, and a little in advance of the posterior opercular border laterally, and, on the lower surface, at about the level of the origin of the ventrals; pectoral base naked. Genital papilla moderate.

First dorsal beginning above the anterior fourth of middle pectoral rays; the length to its origin 2·8–2·9 in length to hypural; its base 2·2–2·5 in its distance from tip of snout, and subequal to postorbital portion of head; first spine about one and one-half times as long as last, and about one and one-third in longest (5th), which latter is rather more than half head; laid back, reaches to, or nearly to, origin of second dorsal. Interdorsal 3·0–4·0 in base of first dorsal, and less than eye. Second dorsal beginning behind level of vent; the length to its origin 1·8–1·9 in length to hypural; its base 2·6–2·8 in its distance from tip of snout, and subequal to combined length of base of first dorsal and interdorsal; its longest (3rd) ray but little longer than succeeding rays, and subequal in large specimens to base of the fin; laid back, fails to reach level of base of middle

caudal rays by less than length of its own last ray, which is relatively longer in larger specimens. Anal beginning about below, or a shade behind, second ray of soft dorsal, and ending just behind soft dorsal; the length to its origin 1·7–1·8 in length to hypural; its base 2·9–3·6 in its distance from the snout, and about two-thirds length of head; similar in general form to, but lower than, soft dorsal; laid back, fails to reach level of base of middle caudal rays by a distance varying from rather more than length of its own last ray, in smaller specimens, to less than two-thirds of same, in larger specimens. Pectoral inserted just anterior to ventral; somewhat narowly rounded; without free silk-like rays; its longest (about 10th) ray rather more than one and one-half times postorbital portion of head, and reaching, when adpressed, about to level of middle of interdorsal. Ventrals united; with a well-developed anterior interspinous membrane; their longest (5th) ray subequal to base of anal, and reaching, when adpressed, nearly, or quite, to vent. Caudal pointed, the median rays, which are somewhat produced, 1·0–1·3 in head.

General colour of body (in formalin) varying above from pale greenish grey to dull greenish brown, below from white to pale, faintly greenish grey. Scales of the back and sides narrowly margined posteriorly with blackish, being minutely and abundantly punctulate with sepia, the punctulations extending over the whole scale in darker specimens, but being confined to the posterior half or two-thirds in lighter examples; scales of ventral surface immaculate. In some specimens there are four rather indefinite dark bands across the back, not, or scarcely, discernible in others, which extend about to the midlateral line, the first at level of first dorsal, second rather behind middle of second dorsal, third just behind that fin, fourth near middle of caudal peduncle. A row of small to moderate dark spots along midlateral line, about nine between axilla and caudal base, the last the most conspicuous of the series. Upper surface and sides of head in some specimens very pale greenish, almost white, minutely punctulated with darker greenish, in others brownish, similarly punctulated, but also coarsely blotched and vermiculated with dark brown; a dark streak from eye towards angle of mouth; lower surface pale greenish grey. Dorsals and anal grossly hyaline, membrane and rays, particularly the latter, punctulated with brown, showing a tendency in darker individuals towards the formation, especially in the dorsals, of rows of spots and bars; extremities of the rays usually blackish. Caudal with about six rows of dark spots, chiefly developed radially. Pectoral faintly dusky greenish, more or less heavily punctulated with brownish. Ventrals pale yellow, occasionally dusky, especially distally, on account of the presence of dark punctulations.

Material examined. Described from five specimens in the collection of the Queen Victoria Museum, Launceston (Reg. Nos. 940 a-e), two lighter individuals, 75 and 67·5 mm. in total length, the

smaller of which is figured, obtained 12th March, 1934, three darker individuals, 84·5, 77, and 72·5 mm. in total length, part of a series of ten, obtained 18th April, 1934.

Locality. River Tamar, Tasmania; first series from Launceston wharf, second series from upper reaches of river near Tamar Island.

Synonymy and Taxonymy. Two main questions arise in regard to the synonymy, first, that of the identity of the species with *Favonigobius lateralis* (Macleay), secondly that of its identity with *Gobius tasmanicus* Whitley.

Johnston himself (1883, p. 120) noted regarding his *G. tamarensis*, 'This species approaches very close to *Gobius lateralis* (Macleay).' Succeeding writers without access to specimens—*e.g.*, Macleay (1884, p. 32), McCulloch and Ogilby (1919, p. 229)—have in general been content merely to quote this observation; but Lord and Scott (1924, p. 81), while according *G. tamarensis* a separate heading, express the opinion it is 'probably identical with' Macleay's species. While presenting considerable general resemblance to *Favonigobius lateralis*, as described and figured by McCulloch and Waite (1918, p. 48; Pl. II, fig. 3), the present species may readily be distinguished from that form by, among other characters, its larger number of scales between pectoral base and hypural, and between anterior dorsal and anal rays, the naked pectoral base, the presence of an extra ray in the dorsal, the notched tongue, and nature of the dentition. The degree to which the laid-back soft dorsal and anal extend towards the caudal base appears to vary in both species with the size of the individual, and to be without diagnostic value.

Gobius tasmanicus Whitley is founded upon a short description, with some general measurements of a specimen 69 mm. long, given, under that name, in Johnston's MS., dealt with by Whitley (1929, p. 62). A comparison of the description of *G. tamarensis* and *G. tasmanicus* shows agreement in the following points:—dorsal and anal radial formulae; height one-seventh of total length; head naked, depressed, one-fourth of total length; snout obtuse, convex; eyes approximated; size 2-3 inches: while both are common in the River Tamar. The positive differences noted include:—branchiostegals 4 in *G. tamarensis*, 5 in *G. tasmanicus;* a small difference in the size of the eye; and a rather marked difference in colouration. The difference in the count of the branchiostegals I cannot bring myself to regard as being of great significance; the variation in the size of the eye is more than covered by the range exhibited by the specimens described above; and while a general comparison of a particularly light coloured, little marked specimen with a particularly dark coloured, much marked specimen might well suggest a specific difference, I find a complete gradation between the two extremes in colour exhibited by individuals between which a detailed examination fails to reveal any other differences. With the doubtful exceptions of 'pectoral reaching to vertical from third ray of second dorsal' in *G. tamarensis*, the pectoral not extending beyond the

origin of that fin in any of my specimens, and 'all the teeth small' in the same species, the characters of *G. tamarensis* and *G. tasmanicus* recorded in the description of one only of the two species, and therefore not directly comparable, are compatible with those of the specimens here described. On the whole, in the light of the information now available, I feel little hesitation in regarding *G. tasmanicus* as a synonym of *G. tamarensis*.

After long deliberation, I place this form in *Arenigobius* Whitley. I do so, however, rather as an indication of its general affinities than with any fixed feeling that, when the last word has been said on the Australian genera, it will necessarily remain there. Though the first step towards the solution of the problem of the relationships of the many Australian species originally described under the general name of *Gobius* was taken when McCulloch and Ogilby (1919) first gave adequate descriptions of, and a key to, some of these, and further important advances were made when Whitley (1928, p. 224) instituted *Berowra,* with *(Gobius) lidwelli* McCulloch as orthotype, and (1929, p. 62) *Nesogobius,* with *(Gobius) hinsbyi* McCulloch and Ogilby as orthotype, and later (1930) proposed seven generic names for other species of *(Gobius)* included in McCulloch and Ogilby's key, it is evident there is still a long way to go before the whole matter reaches finality. The present species exhibits close affinities with the species of *Arenigobius* in the important items of the shape of the tongue, and the character of the dentition, but differs from them in the somewhat produced lower jaw, and the smaller number of dorsal and anal rays: it approaches nearer to *A. semifrenatus* than to the genotype, *A. bifrenatus.* It may be observed that McCulloch and Ogilby (1919, p. 204) place these species in their key, to which Whitley (1930, p. 122) in instituting *Arenigobius* refers, in the division 'breast and pectoral base scaly,' but in describing *A. bifrenatus* state (p. 243) that the scales 'extend forward to above the operculum, leaving the nape and the pectoral base naked.' From *Berowra lidwelli,* which, under 'breast and pectoral base naked,' stands immediately adjacent in the key, the present form is readily separable. It finds its nearest ally among extralimital genera with Australian representatives in *Glossogobius* Gill, from which it seems to differ mainly in the degree of notching of the tongue and in the enlargement of some only of the outer teeth. A review of the information at present at my command leaves me with a suspicion that it may at some time be necessary to establish an Australian genus, intermediate in some respects between *Glossogobius* and *Arenigobius,* in which the present species, possibly accompanied by others, may rest.

Genus **Favonigobius** Whitley, 1930

Favonigobius lateralis (Macleay)

Gobius lateralis Macleay, *Proc. Linn. Soc. N.S.W.* V. 4. 1881. p. 602. *Id.* Waite, *Rec. S. Aust. Mus.* II. 1. 1921. p. 146. fig. 230. *Id.* Lord, *Pap. Proc. Roy. Soc. Tas.* 1922 (1923). p. 70. *Id.* Lord and Scott, *Synop. Vert. Anim. Tas.* 1924. pp. 13 and 81. *Id.* McCulloch, *Aust. Mus. Mem.* V. III. 1929. p. 371.
Rhinogobius lateralis McCulloch and Waite, *Rec. S. Aust. Mus.* I. 1. 1928. p. 48. pl. II. fig. 3.
Favonigobius lateralis Whitley, *Aust. Zool.* VI. 2. 1930. p. 122.

Remarks. This species is not included in either of Johnston's Tasmanian lists, nor is it accredited to Tasmania by McCulloch (1929, p. 371). It first appears, so far as I can ascertain, in the list of Lord (1923, p. 70), which is a simple enumeration of species only; and it is also included by Lord and Scott (1924, pp. 13 and 81), with a reference to Macleay's description, but without records of specimens, or comments. I can find no further mention of it in connexion with Tasmania.

The presence of this species on our local lists appears to be an error. It is, I am inclined to think, traceable to a simple misunderstanding, for which I venture to suggest the following possible explanation. Johnston (1891, p. 33) lists under the heading family Gobiidae two species, namely, *Gobius tamarensis* Johnston and *Callionymus lateralis* Macleay, the Callionymidae being, of course, in Johnston's time included in the Gobiidae—Günther (1861, p. 138), whom Johnston largely followed, placing *Callionymus* and allied genera in his 'fourth group' (virtually subfamily) Callionymina, and Macleay himself (1881, p. 628) not separating in any way his *C. lateralis* from any of the other genera of the Gobiidae as then understood. It seems, in these circumstances, at least possible that—aided perhaps by an unconscious association of ideas centring round the word *lateralis*, an association that might well have been reinforced by Johnston's own direct comparison of *G. tamarensis* with *G. lateralis*—Johnston's record of *Callionymus lateralis* Macleay was inadvertently picked up as *Gobius lateralis* Macleay.

That Johnston's own record really referred to *Callionymus lateralis*, and not to *Favonigobius lateralis*, is placed beyond doubt by the radial formulae accompanying it. Moreover, *Callionymus papilio* Günther, of which *C. lateralis* Macleay is a synonym, is a species well established on our faunal list, and is duly accredited to Tasmania by McCulloch (1929, p. 338).

C. papilio now enters the recently constituted genus *Foetorepus* Whitley (1931, p. 323).

Tasmanogobius, gen. nov.

Diagnosis. Without developed, superficial scales, but with pectinate groups of spines, that probably relate to rudimentary, embedded, non-imbricating scales; transparent. Body elongated, sub-

cylindrical. Pores surrounded by disks, simulating photophores, present in complex system on head, in metameric series on body, and on caudal fin. Head not compressed. Snout blunt. Mouth oblique; jaws subequal. No barbels or cirri. Teeth in several rows anteriorly, those of the outer series much enlarged. Palate toothless. Tongue free anteriorly, produced mesially. Gill-openings extending well forward below; gill-membranes united across a moderate isthmus. Exposed edge of shoulder girdle smooth. Gill-rakers short, stout, about 8 on lower limb of anterior arch. First dorsal with 7 (rarely 6) spines; originating near middle of pectoral; not united with soft dorsal. Soft dorsal and anal similar, the latter slightly the shorter; with about 14-16 rays; ending far in advance of caudal. Pectoral rounded, without specialized rays. Ventrals I, 5, conjoined; with anterior interspinous membrane. Caudal subtruncate; with many procurrent rays. Size apparently small. Myomeres 8 + 18.

Orthotype.—*Tasmanogobius lordi*, sp. nov.

Habitat.—Tasmania.

Tasmanogobius lordi, sp. nov.

(Plate IV, fig. 2; and Text figs. 1 and 2)

B. 6. D. VII [in one paratype VI], 15 [15–16]. A. I, 13 [I, 13–15]. P. 18 [19]. C. 15 + $\frac{8}{8}$ [15 + $\frac{8}{8}$ — 17 + $\frac{10}{10}$]. Gill-rakers short, stout, mamilliform, 8 on lower limb of anterior arch.

Depth 7·3 [7·1–8·0] in total length, and 6·2 [6·0–6·7] in length to base of middle caudal rays. Head 5·1 [4·6–4·9] in total length, and 4·3 [4·0–4·1] in length to base of caudal. Snout 1·0 [0·96–1·1] in eye, and 3·9 [3·9–4·4] in head. Interorbital width 3·8 [3·1–4·4] in eye. Caudal peduncle 5·7 [6·2–7·1] in length to base of caudal, and greater than base of first dorsal; its depth 2·2 [1·8–2·2] in its length, and about three times head.

Head naked, transparent. Its posterior width, and width at level of hinder orbital margin subequal to corresponding depths. Snout broadly rounded from above, obtusely conical in profile. Anterior nostril large, in a short, rather wide tube, placed about midway between orbit and upper lip, and subcontinuous with the short, scarcely developed tube of the posterior nostril, which opens immediately in advance of orbit. Eyes moderate, usually cutting the dorsal profile, the transparent covering that is continuous with the skin of the head always doing so. Interorbital space slightly convex. Mouth decidedly oblique; jaws subequal anteriorly, the lower sometimes slightly projecting; maxillary extending to, or slightly beyond, level of anterior orbital margin. No barbels or cirri. Premaxillary teeth in a single cardiform row in the hinder third of the jaw; anterior to which they are chiefly in two rows, with indications of an intercalated third row near the middle of the series; those of

the outer row all large, recurved, rather blunt near the symphysis, increasing in size and acuteness backwards to just beyond middle of jaw; remainder fairly acute, somewhat recurved, subequal, about half as large as the largest of the outer row. Palate toothless. Mandibular teeth in about three rows anteriorly, decreasing to a single row just before they cease behind; those of the outer row greatly enlarged, elongate, rather blunt, markedly recurved, subhorizontal anteriorly, becoming smaller, relatively stouter, more nearly vertical as they continue backwards; those of the middle row moderate throughout, subequal posteriorly to those of the outer row, moderately acute, recurved; those of the inner row smallest, most acute, least recurved. Tongue free in its anterior half; its broad anterior margin produced mesially. Gill-openings continued forward below about to level of posterior preopercular margin; gill-membranes united across

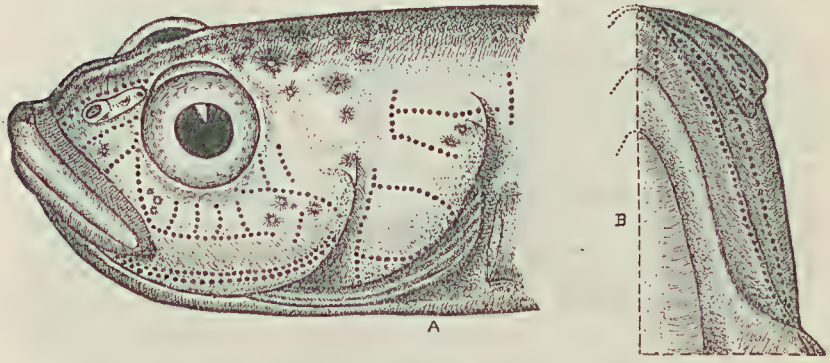

Fig. 1.—*Tasmanogobius lordi*, sp. nov.
A.—Head, lateral aspect, slightly tilted. × 10. B.—Lower jaw, ventral aspect of left half. × 10.

a moderate isthmus, subequal to snout. Exposed edge of shoulder girdle smooth.

Head with a complex system of pores (Text fig. 1, A, B): the double series running forward towards the lower lip (Text fig. 1, A) continuous or subcontinuous with the double series on the chin (Text fig. 1, B). Each pore surrounded by a sharply defined, more or less opaque disk, 80–100 μ in diameter, and set $\frac{1}{5}$–$\frac{2}{5}$ of its diameter from its neighbour, the whole structure somewhat simulating a photophore.

Body transparent, elongated, subcylindrical; breadth at origin of soft dorsal 1·3 [1·1–1·5] in depth there, and breadth at termination of soft dorsal 1·1 [1·1–1·4] in depth there. Pore-disks, the detailed structure of which, as seen in a slide of the skin, examined with a Natchet No. 7 objective and a Leitz No. O ocular, is shown in Text fig. 2 B, are present in subvertical or forwardly convex rows

(Text fig. 2 A) along the side, one to each myomere, the posterior series extending for about five-sixths of the depth of the body, and comprising about a dozen disks, the anterior series usually shorter, with fewer disks. Genital papilla small to moderate.

Without developed, superficial scales; but with non-imbricating pectinate groups of spines, which probably relate to rudimentary scales, arranged in one or three rows posteriorly, as indicated diagrammatically in Text fig. 2 A, and in five or seven similarly staggered rows anteriorly. Usually the spines are wholly embedded, and in preserved specimens invisible without dissection: in several individuals, however, they pierce the integument in the region covered by the adpressed pectoral, presenting a curious superficial resemblance to the spine-groups of some species of Cyclopteridae, *e.g.*, *Lethrotremus vinolentus* Jordan and Starks. Spines 3–12 in a series,

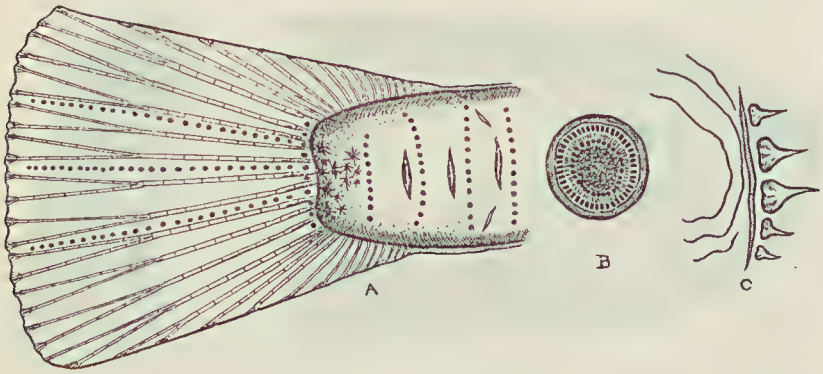

Fig. 2.—*Tasmanogobius lordi*, sp. nov.
A.—Caudal peduncle (with position of basal plates of spine-groups indicated diagrammatically) and caudal fin. × 10. B.—Pore disk. × 150. C.—Spine group and associated scale structure. × 100.

the larger groups restricted to the anterior portion of the body; with broad, non-contiguous bases; each series associated with, but apparently not in contact with, an amphioxid spicule-like basal plate (Text fig. 2 C), in advance of which are at times to be found indications of ordinary scale structure.

First dorsal beginning at, or behind, middle of pectoral; the length to its origin 3·0 [2·9–3·0] in length to base of middle caudal rays; its base 2·7 [2·5–3·3] in its distance from tip of snout, and subequal to postorbital portion of head; first spine two to three times as long as last, and about one and one-third in longest (3rd), which latter is about one-third length of head. Interdorsal 1·5 [1·1–1·9] in base of first dorsal, and about one and one-half times eye. Second dorsal beginning shortly behind vertical from vent; its height about two-thirds that of the body beneath it; the length to its origin 1·9 [1·8] in length to base of middle caudal rays; its base 1·9 [1·8–2·0] in its

distance from tip of snout, and about two and one-half times base of first dorsal; first ray about one and one-quarter times last, and about twice in longest (3rd), which latter is subequal to interdorsal. Anal beginning below interval between 1st and 2nd rays of soft dorsal, and ending about below the penultimate ray of that fin; the length to its origin 2·1 [2·0–2·1] in length to base of middle caudal rays; its base 2·1[2·0–2·1] in its distance from tip of snout, and about one and one-tenth length of head; similar in form and subequal in height to soft dorsal. Pectoral inserted in advance of ventrals; rounded, obscurely pointed; the majority of the rays branched; upper rays not free from membrane; longest (about 11th) ray rather longer than portorbital portion of head, and reaching, when adpressed, to below 4th [3rd-5th] dorsal spine. Ventrals united, somewhat cup-shaped, not adnate to belly; rays deeply divided, doubly forked from, and usually including, the second onwards; 5th ray longer than 4th, but not greatly so, and subequal to interval between anterior margin of eye and posterior margin of operculum; reaching, when adpressed to, or, a little beyond, midway between its origin and origin of anal. Caudal rounded truncate, the middle of the fin extending horizontally backward beyond the postero-lateral angles by about one-fifth of the length of the median rays, which latter are 1·3 [1·4–1·5] in head; a well-developed series of 8 or 10 procurrent rays above and below. Low ridges connect the caudal with the soft dorsal and the anal fins. Pore-disks on caudal in a vertical basal row, from which run back a midlateral row, and, on either side of it, separated by two, sometimes three, rays, a lateral row: this pattern, which is indicated on one side only of the membrane in Fig. 1 C, occurs on both surfaces of the membrane.

Total length 34·4 mm. [31·7 mm.–34·3 mm.]; length to base of middle caudal rays 29·2 mm. [28·6 mm.–29·3 mm.].

In life transparent; scarcely discernible in the water except for the conspicuous dark eyes. A row of about nine small fawn markings along the midlateral line, the first, below the anterior third of the spinous dorsal, usually the darkest, and regularly forming a narrow subvertical bar, ½–⅔ as high as the body; the third, fifth, and seventh, below the origin, middle, and termination of the soft dorsal respectively, and the ninth, at the end of the caudal peduncle, showing some tendency towards vertical elongation, and commonly larger than the alternating ones, which are subcircular; in one paratype only the posterior three markings are present, the last of these alone being conspicuous. Fawn markings, variable in character, occur on the back. When best developed, as in the holotype, they take the form of seven double bars, made up of subcontinuous longitudinally elongated blotches, and extending slightly on to the sides; the first series in advance of, second below, spinous dorsal, third on interdorsal, fourth-sixth below soft dorsal, seventh near base of procurrent caudal rays. In paratypes they tend to be broken up into spots, each double series, except the first, which in several

cases shows a quincunical arrangement, coming more or less definitely to consist of four dots disposed roughly as at the angles of a square. A row of from eight to twelve small spots along either side of base of anal, as often as not continued back to the anterior procurrent caudal ray. A conspicuous Y-shaped series of dark dots on the ventral surface, the unpaired limb extending mesially from about level of preopercular margin to base of ventrals, where it forks to give rise to two shorter limbs covered, but not hidden, by the conjoined fins. Head variably spotted and punctulated; but regularly with well-marked streak from below eye to angle of mouth, and behind eyes two small blotches, which may be subcontinuous anteriorly, or posteriorly, or both; usually also with more or less definite spots on cheek, behind middle of eye, near posterior preopercular margin, and on operculum; in some specimens two short rows of spots run forward from eye along dorsal surface of snout; lips with faint irregular blotches and some minute punctulations; ventral surface of head immaculate. Pectoral base, which is well developed, lightly punctulated. Dorsals and anal colourless to the naked eye, but all with microscopic punctulations, most numerous basally and posteriorly in the first dorsal, and externally in the other fins. Caudal with dusky marking at base, in sequence with lateral body-series; in some individuals with groups of brownish punctulations forming two or three more or less evident transverse arcs. Pectoral colourless, with a few scattered microscopic dots, particularly basally. Ventrals with numerous punctulations, usually rendering them dusky, particularly distally.

Material examined. Described from the holotype (Plate IV, fig. 2), five paratypes, and mounted paratypic material. Holotype, a paratype, and slides in the collection of the Queen Victoria Museum, Launceston (Reg. Nos. HT.941a, PT.941b, and PT.sl. 941c-g respectively). Paratypes will be offered to the British Museum (Natural History), London; Australian Institute of Anatomy, Canberra; Australian Museum, Sydney; and National Museum, Melbourne.

Locality. Mouth of the River Leven, Tasmania. Not uncommon, in association with *Nesogobius hinsbyi*, in sandy pools formed by the retreating tide behind the retaining wall near the breakwater, West Ulverstone. Several days' collecting in the neighbourhood, while rewarded with other specimens of *Nesogobius hinsbyi*—and, among non-gobioid material, *Atherina tamarensis*, and the usual *Pictiblennius tasmanianus*, *Cristiceps australis*, *Clinus perspicillatus*, *Alabes* spp., and *Parvicrepis cardinalis*—failed to yield further examples.

Named in honour of the late Clive Errol Lord, Director of the Tasmanian Museum, and for fifteen years Secretary of this Society, the most notable local worker in systematic ichthyology since R. M. Johnston's time.

Remarks.—I am unable to suggest the affinities of this form, and have been constrained to establish a new genus for its reception. In addition to the fact that it shares with the otherwise dissimilar

Nesogobius hinsbyi the distinction of being the only known Australian goby with seven dorsal spines, it appears to be readily distinguishable upon other grounds from the described Australian genera; nor are its characters compatible with those of any of the extralimital genera to descriptions of which I have access. My grateful thanks are tendered to Mr. Gilbert P. Whitley, Ichthyologist, the Australian Museum, Sydney, who, in response to inquiries, very kindly referred for me to some extralimital literature on the family—in particular Jordan and Seale's review of the gobies of Oceania—not available in Tasmania.

Summary

1. Four species of Gobiidae have been accredited to Tasmania. Notes on these are given, as indicated seriatim below, and a new genus is described.

2. *Nesogobius hinsbyi* (McCulloch and Ogilby). Life-colours, habits, variation, and new localities recorded; general observations and remarks.

3. *Arenigobius tamarensis* (Johnston). Redescribed and figured; its affinities with *Favongobius lateralis* (Macleay), and its generic status discussed.

4. *Gobius tasmanicus* Whitley. Shown to be probably a synonym of *Arenigobius tamarensis* (Johnston).

5. *Favongobius lateralis* (Macleay). Considered to be accredited to Tasmania in error; an explanation of its presence on some local lists suggested.

6. *Tasmanogobius*, gen. nov., described; orthotype, *Tasmanogobius lordi*, sp. nov., described and figured.

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EXPLANATION OF PLATE

PLATE IV—

Fig. 1.—*Arenigobius tamarensis* (Johnston). Topotypical specimen. Total length 67·5 mm.

Fig. 2.—*Tasmanogobius lordi*, sp. nov. Holotype. Locality, mouth of River Leven, Tasmania. Total length 34·4 mm.

Fig. 1.

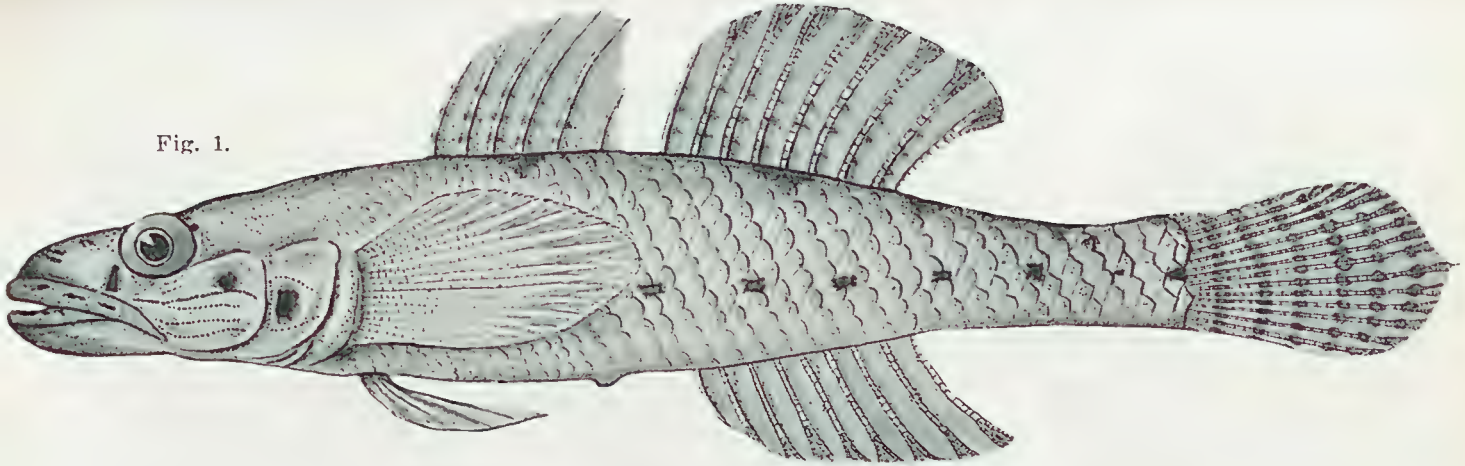


Fig. 2.

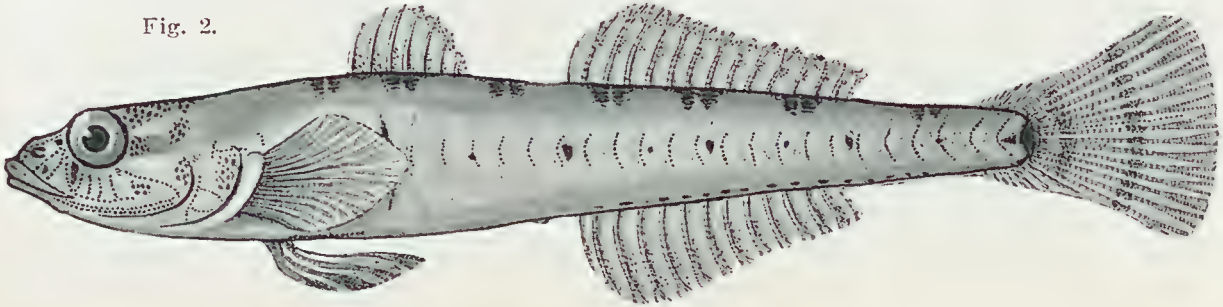
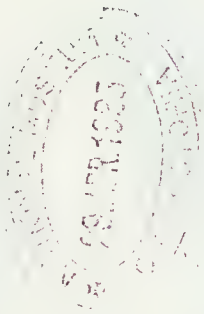


Fig. 1.—*Arenigobius tamarensis* (Johnston). [E.O.G.S. del.]

Fig. 2.—*Tasmanogobius lordi*, sp. nov.



Observations on Some Tasmanian Fishes
Part II

By

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With One Plate

(Read 3rd December, 1934)

The present paper has the same general aims as, and may be regarded as being a continuation of, a previous contribution by the writer (1934): its precise scope is summarized in the concluding paragraph.

Registration numbers are those of the Queen Victoria Museum, Launceston.

Family Hemiscylliidae

Genus **Parascyllium** sp. nov.

Parascyllium multimaculatum, sp. nov.

(Plate V, fig. 1)

Description. Head to last gill-slit (111·5 mm.) 2·1 times its width at level of eyes (52), and 6·4 in total length (710). Depth of body, between pectoral and anal, where it is greatest, (65) 1·7, at origin of second dorsal (26) 4·3, in head. Eye (13) 9·0 in head, 2·6 in snout (34), which is 3·3 in head. Preoral portion of head (9) 3·8 in width of mouth (34).

Body elongate, somewhat depressed anteriorly, subcylindrical posteriorly; its width at origin of first dorsal (35) rather more than its height there (32). Head large, greatly depressed; snout rather large, broadly rounded from above, depressed and obtuse in profile. Spiracle minute (less than 1 mm. in diameter), behind and below posterior angle of eye, its distance from which (10) is 1·3 in diameter of eye (13), and 3·0 in interorbital width (30). A longitudinal fold beneath eye. Gill-slits.—1 < 2 < 3 : 4 < 5; first (6) 2·3 in last (26), which latter is 1·3 in snout; first nearer to spiracle than to origin of pectoral; fourth and fifth close together, over base of pectoral. Internarial distance (18) 2·7 in interspiracular distance (48). Nasal cirrus short, fairly thick, reaching to lip; exterior nasal fold with a short, blunt lobe at its postero-external angle. Lower labial fold extending about halfway to middle of jaw; continued well round angle of mouth.

Teeth in upper jaw in about seven closely set rows mesially; small, elongated, bulbous just above the base, the distal half flattened and acute; in lower jaw similar in number and form, but with the basal bulb sometimes forming a pair of incipient lateral cusps.

First dorsal originating further from tip of snout (360) than from tip of caudal (350); its base (40) 1·2 in its height (48), and 2·5 in interdorsal space (101), which latter is equal to length to origin of pectoral. Base of second dorsal equal to that of first dorsal, and subequal to its own height (42). Dorsals subequal in form, apex rounded, posterior margin slightly concave mesially, and forming rather more than a right angle with lower margin. Anal low, ending at level of origin of second dorsal; length to its origin (453) 1·3 in length to origin of superior lobe of caudal (582); its base (46) 2·1 times its height (21). Pectorals broadly rounded; base (33) 1·8 in length (61), which latter is 3·2 in total spread of these fins (194). Ventrals longer than broad, their length along inner border (67) 1·2 times length of main cartilage of clasper (58); outer margin broadly rounded; posterior angle pointed; length to their origin (264) 2·2 in length to origin of inferior lobe of caudal (571). Greatest depth of caudal (32), occurring at first fourth of portion in advance of notch, 4·3 in its total length; depth at notch (18) 1·7 in length of portion behind notch.

General colour pale grey, tinged with brown, becoming almost white below, particularly in advance of ventrals. With about ten rather indeterminate bars of rusty brown on the sides, disposed as shown, in general subtriangular, the apices not, but exceptionally almost, attaining the ventral profile, the broad bases virtually confluent on the back; one of these bars, a shade darker than the rest, forms an ill-defined nuchal collar, tapering on the sides, and ceasing at the horizontal level of the anterior insertion of the pectoral, just below the gill-slits, the posterior three of which it embraces. Sides and back of body ornamented with very numerous scattered small dark brown spots, often somewhat darker on the body-bars; about 50 of these spots on either side between the verticals from the origins of the dorsals. Dorsal and lateral surfaces of head in advance of spiracles uniform dark brown; its whole ventral surface whitish, except preoral region, which is light slate grey.

Dorsals mainly concolorous with body-bars, a shade lighter along the posterior border; each with ten or twelve dark spots. Pectoral and ventral concolorous above with the dorsals, beneath with the lower preoral region of head; on both surfaces somewhat paler towards the posterior and inner borders; each pectoral with above half a dozen, each ventral with about a dozen, dark spots. Anal concolorous with ventral surface of body; with one large elongated, and three or four small, rounded dark spots. Upper half of caudal concolorous with body-bars, bearing dark markings that are elongated to form several small longitudinal stripes along the superior border; lower half lighter, with a number of subcircular dark spots.

Material examined. Described and figured (Plate V, fig. 1) from the unique holotype male in the collection of the Queen Victoria Museum (Reg. No. HT983). The specimen, which was secured by Mr. C. Andrews, was mounted and presented by Mr. G. R. F. Green: I had, however, previously examined it, and all dimensions recorded above are those of the fresh fish.

Locality. Tamar Heads, Northern Tasmania.

Affinities. *Parascyllium multimaculatum* is readily distinguished from the other members of the genus by the insertion of the first dorsal behind the middle of the total length—a character which, while it would certainly provide a convenient subgeneric criterion, is, I think, best regarded, at any rate for the present, as being of specific value only—and by the colour-markings.

From *P. variolatum* Duméril and *P. ferrugineum* McCulloch it is further chiefly distinguished by having the anal inserted wholly in advance of the second dorsal; also from the first species in possessing a supplementary lobe to the outer labial fold, and in the shape of the vertical fins, and from the second species in the size of the gill-openings, and the position of the spiracle: from *P. collare* Ramsay and Ogilby, to which, on the whole, it perhaps most closely approaches, it is further separable mainly in having the nasal cirrus reaching the lip, the first gill-opening nearer to spiracle than to pectoral, and in the excavate posterior margins of the dorsals.

Specific name in allusion to the numerous brown spots.

Family ANGUILLIDAE

Genus **Anguilla** Shaw, 1803

Anguilla reinhardtii Steindachner

Anguilla reinhardtii Steindachner, *Sitzb. Akad. Wiss. Wien.* LV. 1. 1867. p. 15. figs. a-b. *Id.* McCulloch, *Aust. Mus. Mem.* V. I. 1929. p. 64.
Anguilla marginipinnis Macleay. *Proc. Linn. Soc. N.S.W.* VIII. 1883. p. 210.

Remarks. In a previous contribution (1934, p. 36) the position of this species on the Tasmanian list was discussed, and some notes were given on the dimensions attained by large individuals.

A large specimen (not preserved), obtained in the fluming of the municipal hydro-electric system between Duck Reach and the Power Station, near Launceston, on 16th April, 1934, yielded the following measurements. Total length 1658 mm., length to origin of dorsal 488 mm., length to middle of vent 705 mm., length to origin of anal 725 mm., length to origin of pectoral 208 mm., snout 42 mm., eye 17 mm., interorbital width 60 mm., girth 440 mm., weight (the day after capture) 33 lbs.

Lower jaw markedly projecting. Maxilla reaching to vertical of hinder margin of eye. Teeth typical. General colour brownish,

almost black, above, lighter below. The $\frac{a - d}{t} \times 100$ value is 13·1, which is well above the average (10·72) and close to the maximum (13·2) value as determined by Schmidt (1928, p. 203).

Family SYNGNATHIDAE

Genus **Farlapiscis** Whitley, 1931

Farlapiscis breviceps (Peters)

Hippocampus breviceps Peters, *Monatsb. K. Pr. Akad. Wiss. Berlin* 1869 (1870). p. 710. *Id.* McCulloch, *Aust. Mus. Mem.* V. I. 1929. p. 95: and of authors generally to that date.
Farlapiscis breviceps Whitley, *Aust. Zool.* VI. 4. 1931. p. 313.

Record. In May, 1934, the Queen Victoria Museum obtained by exchange an example of this species (Reg. No. 984), secured at Denne's Point, Bruny Island, in April, 1934. The specimen is an adult male, measuring some 70 mm. in total length.

Remarks. Though this species is recorded by Johnston, both in his first list (1883, p. 135), where it is noted as 'common,' and in his second list (1891, p. 37), and is included in the lists of Lord (1923, p. 64) and Lord and Scott (1924, pp. 8 and 41), and is also credited to Tasmania by Waite and Hale (1921, p. 323), its range is recognized by McCulloch (1929, p. 95)—possibly through the lack of authenticated Tasmanian specimens—as extending only to South Australia, Western Australia, and New South Wales.

The present record serves to confirm the traditional inclusion of *Farlapiscis breviceps* in our faunal list.

Family HYPOPLECTRODIDAE

Genus **Nannoperca** Günther, 1861

Nannoperca tasmaniae (Johnston)

Microperca tasmaniae Johnston, *Pap. Proc. Roy. Soc. Tas.* 1882 (1883). p. 110.
Nannoperca tasmaniae McCulloch, *Aust. Mus. Mem.* V. II. 1929. p. 157.

Locality. In his description of the species Johnston observed, 'Abundant in the rivers of the South and North Esk. The young are found in large numbers in the shallow lagoons having connection with the rivers during some portion of the year.' No records of locality—indeed, few, if any, data based on actual material—other than Johnston's seem to have been published. During the last few years we have met with the species in several of the localities mentioned by Johnston, and, in view of its apparently restricted

distribution, it is worthy of record that on 18th September, 1934, a specimen, 65 mm. in total length, was received at the Museum from Dunorlan—*i.e.*, from the Rubicon River—where it is said by the sender not previously to have been observed.

I hope on a future occasion to illustrate this species, and to discuss its relationships with *N. australis* (Günther), to which it is closely allied, and with which it has been proposed it should be associated (McCulloch and Waite, 1918, p. 45) in a subgenus *Nannoperca*.

Family Scorpidae

Genus **Scorpis** Cuvier and Valenciennes, 1832

Scorpis aequipinnis Richardson

Scorpis aequipinnis Richardson, *Zool. Voy. Erebus and Terror.* (*Fish*, 1848). p. 121. *Id.* McCulloch, *Rec. Aust. Mus.* XI. 7. 1917. p. 177. fig. 2. *Id.* McCulloch, *Aust. Mus. Mem.* V. II. p. 237.

Record. A specimen, 326 mm. in total length, from near George Town, was presented to the Queen Victoria Museum (Reg. No. FR814) by Mr. T. Tyler, fishmonger, Launceston, on 2nd December, 1933.

Remarks. First record of the species for Tasmania. I examined, however, another specimen from the same locality, which was not available for preservation, on 23rd November, 1933.

Johnston (1883, p. 111), citing Allport MS., admitted *S. georgianus* to his list, remarking, 'Rare. Not seen'; but included it without comment later (1891, p. 30): this species is listed by Lord (1923, p. 68), while Lord and Scott (1924, p. 65) observe 'occasionally taken on the Northern Coasts.'

In the Check-List McCulloch (1929, p. 237) gave the locality of *S. aequipinnis* as Western Australia only, and that of *S. georgianus* as Western Australia, Tasmania, and South Australia, though earlier, in reviewing the genus, he had admitted 'South and South-western Australia,' mentioning (1917, p. 178) a specimen from Adelaide in the Australian Museum. In the interval Waite (1921), who notices McCulloch's 1917 revision in his references, included both species in his South Australian catalogue—observe, however, Waite's convention concerning 'South Australia' (1921, p. 1)—illustrating only *S. aequipinnis* (fig. 172), and remarking regarding *S. georgianus* (p. 112), 'It is possible that this may prove to be the young of *S. aequipinnis*,' an observation suggested, it may be presumed, by the relatively more produced anterior dorsal and anal rays, and the somewhat larger eye of *S. georgianus*. In a supplement to the work cited Waite (1927, p. 230) states, concerning *Scorpis*, 'Our form, which is frequently banded, is referable to the type-species from

King George's Sound, Western Australia' (*i.e., S. georgianus)*, and deletes *S. aequipinnis* in favour of *S. georgianus.*

As a contribution to the vexed question of the distribution of these two species, I place on record below a short description (drawn up, to facilitate comparison, substantially in the form adopted in McCulloch's 1917 survey of the genus) of the Tasmanian specimen here identified as *S. aequipinnis.*

Description. D. IX, 27. A. III, 25. P. 18. V. I, 5. C. 17. Depth at the ventrals (111 mm.) 2·3 in length to hypural joint (254); head (64) 4·0 in same. Eye (16) 4·0, second dorsal ray (50) 1·3, second anal ray (50·5) 1·3, in head. Upper profile evenly convex above the eye, subequal throughout to lower profile. Mandible long, rather narrow, reaching to about one-fifth of orbital diameter beyond anterior orbital margin, its width (8·5) subequal to its distance from the eye (8). Outer row of teeth in each jaw much larger than the others. Scales small; 107 above lateral line from its origin to hypural joint; 17 between base of second dorsal ray and lateral line; 21 between base of pectoral and ventral spine. Dorsal and anal fins produced anteriorly, the anterior rays projecting beyond the middle rays, which are three-fourths of eye-diameter in height, and one and one-quarter times eye-diameter in total length, by a vertical distance subequal to the vertical median height of the fins. No dark cross-bands; uniform brownish black above, somewhat lighter below the lateral line.

Family Girellidae

Genus **Melambaphes** Günther, 1863

Melambaphes zebra (Richardson)

Crenidens zebra Richardson, *Zool. Voy. Erebus and Terror. (Fish,* 1846). p. 70.
Tephraeops zebra Waite, *Rec. S. Aust Mus.* II. 1. 1921. p. 114. fig. 115 (references and synonymy).
Melambaphes zebra McCulloch, *Aust. Mus. Mem.* V. 11. 1929. p. 240.

Record. Two specimens, 354 mm. and 357 mm. in total length, both from near George Town, were purchased by the Queen Victoria Museum (Reg. Nos. 985 a-b) from Mr. T. Tyler, fishmonger, Launceston, on 23rd November, 1933, and 7th December, 1933, respectively.

Remarks. According to McCulloch (1929, p. 240), this species has been recorded from all the Australian States except Tasmania and Queensland. A local record, however, appears to have been missed, as Lord (1925) noted it from the East Coast, remarking (p. 52), 'it is strange that its occurrence there should have been overlooked.'

The present records from the north of the State are not, therefore, unexpected, and serve to confirm the inclusion of this species in the Tasmanian faunal list.

Family CLINIDAE

Genus **Clinus** Cuvier, 1816

Clinus johnstoni Saville-Kent

Clinus johnstoni Saville-Kent, *Rept. Fish. Dept. Tas.* p. 13. *Id.* Johnston, *Pap. Proc. Roy. Soc. Tas.* 1890 (1891). p. 33. *Id.* McCulloch, *Proc. Linn. Soc. N.S.W.* XL. 1915. p. 273. pl. XXXVII. fig. 2. *Id.* Lord, *Pap. Proc. Roy. Soc. Tas.* 1922 (1923). p. 70. *Id.* Lord and Scott, *Synop. Vert. Anim. Tas.* 1924. pp. 13 and 82. *Id.* McCulloch, *Aust Mus. Mem.* V. III. 1929. p. 349.

Previous Descriptions. Saville-Kent's description of the type, which was 'preserved alive for some time in the tanks of the fishery,' merely notes that it belongs to the genus *Clinus*, and 'differs from the single species, *C. despicillatus* [= *C. perspicillatus* Cuv. and Val.] hitherto taken in these waters, and which averages the length of 4 or 5 inches only, in its larger dimensions, 15 inches, in the great development of the nostril tentacles, and in other characters of specific value.' Johnston (1891, p. 33) recorded the fin-counts as follow:—D. 2–3: 32–33: 5. A. 2·25–26. V. 1·3; but gave no further details. The species was first fully described and figured by McCulloch (1915), whose account is based on two specimens, 227 mm. and 341 mm. in total length, in the Australian Museum, though he observes, 'I have also examined a still larger specimen in the Tasmanian Museum, which is possibly the type of the species.'

Material examined. An examination of a Tasmanian specimen of a *Clinus* (precise locality not recorded; probably Tamar Heads), 347 mm. in total length, in the Queen Victoria Museum (Reg. No. 887), which, in spite of its exhibiting some variation, seems clearly to be referable to *C. johnstoni* Saville-Kent, extends the recorded range of some of the radial formulae, and discloses some differences in proportion.

Fin-Counts and Proportions. D. 2, 33: 4 + 2. A. 2, 26. P. 16. V. 3. C. $10 + \frac{1}{1}$

Length from tip of snout to end of bony operculum (72 mm.) 4·1, depth at origin of anal (69) 4·3, in length to hypural joint (296). Eye (11·5) 7·0, snout (15) 5·4, in head. Interorbital width (9·5) 1·2 in eye. Second dorsal spine (25·5) 3·2, first dorsal ray (41) 2·0, fourth last anal ray (39) 2·1, in head. Median rays of pectoral (50) 1·6, of ventral (44) 1·8, of caudal (51) 1·6, in head.

Description. The following minor additions to McCulloch's description may be noted. Approximate numbers of pores in the anterior horizontal, oblique, and posterior horizontal sections of the lateral line are 25, 6, and 27 respectively. Supraorbital tentacle has about seven lobes.

Variation. The chief variations from McCulloch's description are:—(*a*) the interesting presence of an extra ray in the dorsal, and the occurrence, as noted in the formula above, of differential spacing of the dorsal rays, not previously observed in the species; (*b*)

additional ray in pectoral; (*c*) smaller eye (7·0, as against 5·2–6·1, in head); (*d*) shorter snout (5·4, as against 4·6–4·7, in head); (*e*) anal begins below 11th spine of second dorsal (about below 13th in McCulloch's figure). The specimen agrees with one of the two described by McCulloch in that the pectoral fails to attain to level of first anal spine (reaching about to vent), and with one of these two specimens in having lost all cross-bars on the body, no doubt as the result of preservation.

The 17th and 26th spines of the second dorsal are injured or malformed in the specimen, being only about two-thirds as long as their neighbours, and not reaching to the border of the membrane, which maintains an uninterrupted and normal line outside their tips.

Genus **Petraites** Ogilby, 1885

Petraites incertus McCulloch

Petraites incertus McCulloch, *Proc. Linn. Soc. N.S.W.* XL. 1915. p. 275. pl. XXXVII. fig. 3. *Id.* McCulloch, *Aust. Mus. Mem.* V. III. 1929. p. 350.

Material examined. Three specimens of a *Petraites*, 123 mm., 254 mm., and 211 mm. in total length, in the collection of the Queen Victoria Museum (Reg. Nos. 0840 a-c) are evidently referable to *P. incertus* McCulloch, the first two being from the type-locality of that species (River Tamar), the third, though known to be Tasmanian, being without precise locality-record. As no specimens other than the two syntypes appear to have been the subject of published description, it sems advisable to place on record the data afforded by an examination of the present examples. With the fin-counts and proportions, given below, the corresponding values for the syntypes, 205 mm. and 216 mm. long, are noted [in square brackets] for comparison.

Fin-Counts and Proportions. D. 3, 29: 4–5 [3, 29: 4]. A. 2, 24 [2, 23–24]. P. 11 [11]. V. 3 [3]. C. 9–9 + $\frac{1}{1}$ [9].

Head 3·0–3·5 [3·8–4·1], depth before anal 4·6–4·9 [4·3–4·9], in length to hypural. Eye 5·5–6·8 [5–5·1], snout 3·3–4·3 [3·7–3·8], in head. Interorbital width 1·5–1·8 [1·8–2·1] in eye. First dorsal spine 1·7–2·1 [1·6–1·9], first dorsal ray 1·8–2·0 [1·6], fourth last anal ray 1·9–2·7 [1·4–1·9], in head. Median pectoral ray 1·6–2·0 [1·3], median ventral ray 1·7–1·9 [1·4–1·5], median caudal ray 1·5–1·9 [1·3–1·6], in head.

Description. The following additions may be made to the original description. Approximate numbers of pores in the anterior horizontal, oblique, and posterior horizontal sections of the lateral line are 21–23, 4–5, 28–23 respectively. Anal begins below 11th spine of second dorsal. Inner ventral ray is 2·0–2·6, and outer 1·1, in median ray. Orbital tentacle, laid back, reaches to base of 1st spine, or to between

bases of 1st and 2nd spines of first dorsal. One specimen affords some indications of the second dorsal and anal having been crossed by about six and about five oblique bars respectively, while the first dorsal has apparently borne some three or four subcircular blotches between the 1st and 2nd spines, five or six between the 2nd and 3rd spines, and two or three behind the 3rd spine.

Variation. Apart from the differences in fin-counts and proportions to which attention has been called above, the most noteworthy variation relates to the position of the first dorsal. This fin originates, as far as can be judged from the figure of one of the syntypes, virtually at (about $\frac{1}{15}$ of an eye-diameter behind) the posterior level of the eye, while in the present specimens it originates at from one-third to rather more than one-half an eye-diameter behind the orbital margin.

Affinities. These specimens would seem to indicate that the species is a well-defined one. As regards its relation to some of the early, imperfectly characterised species—a matter on which McCulloch expressed uncertainty, both implicitly in the specific name, and explicitly in his description—after a careful comparison of the specimens with the meagre published accounts of these, I can only say, with the author of the present species (p. 276), 'They do not wholly agree with any of the descriptions.'

Family ANTENNARIIDAE

Genus **Rhycherus** Ogilby, 1907

Rhycherus filamentosus (Castelnau)

(Plate V, fig. 2)

Chironectes filamentosus Castelnau, *Proc. Zool. Acclim. Soc. Vict.* I. 1872. p. 244.
Chironectes bifurcatus McCoy, *Prodr. Zool. Vict.* II. dec. XIII. 1886. p. 87. pl. CXXIII.
? Rhycherus wildii Ogilby, *Proc. Roy. Soc. Qld.* XX. 1907. p. 18.
Rhycherus filamentosus McCulloch and Waite, *Rec. S. Aust. Mus* I. 1. 1918. p. 70. pl. VI. fig. 3 and text-fig. 31. *Id.* McCulloch, *Aust. Mus. Mem.* V. III. 1929. p. 406.

Record. A specimen, 216 mm. in total length, caught at Tamar Heads by Mr. C. Andrews, was donated to the Queen Victoria Museum (Reg. No. FR 982) by Mr. T. Cannon, fishmonger, Launceston, on 2nd March, 1934.

First record for Tasmania.

Remarks. The specimen agrees in general reasonably well with the Victorian individual described and figured by McCoy (1886) and with the South Australian examples dealt with by McCulloch and Waite (1918). Like these specimens it departs rather markedly from the description of *Rhycherus wildii* Ogilby, the haplotype of the genus, which Ogilby (1907, p. 19) explicitly states 'differs considerably from *Chironectes bifurcatus* McCoy,' but which McCulloch

and Waite regard as conspecific with that form, and hence as synonymic with *R. filamentosus* (Castelnau)—a position maintained by McCulloch in the Check-List. Not having had an opportunity of examining the type of *R. wildii*, I cannot express a definite opinion on the matter, and can only comment that a comparison of the description by Ogilby with that by McCoy and that by McCulloch and Waite reveals some rather striking discrepancies, particularly in general proportions and in the form of the fins.

Compared with the continental examples described and figured by McCoy and by McCulloch and Waite, the present specimen exhibits the following differences.—(*a*) maxillary, instead of reaching to below hinder portion of eye, just fails to reach level of eye-tubercle; (*b*) illicium, instead of being shorter than, is two-thirds as long again as, naked supporting rod; (*c*) a yellowish blotch is present on the base of the membrane of the soft dorsal near the middle of the fin; (*d*) minor variations in proportion and colouration. The acquisition of further material may perhaps show that these variations entitle the Tasmanian form to subspecific distinction.

It is of interest to observe, as an indication of the perfection to which cryptic colouration is carried in this species, that the remarkable lichenoid blotches on the body occur also on the inside of the mouth—doubtless held open during 'angling'—where they form pearly white patches on the bluish grey tongue. Pale greenish lichenoid spots also delicately mottle much of the external surface of the pectoral.

Summary

1. Some general observations are made on *Anguilla reinhardtii* Steindachner, *Nannoperca tasmaniae* (Johnston), *Clinus johnstoni* Saville-Kent, and *Petraites incertus* McCulloch.

2. Records are noted confirming the inclusion in the Tasmanian faunal list of *Farlapiscis brevicеps* (Peters), and *Melambaphes zebra* (Richardson).

3. Additions to the Tasmanian faunal list comprise *Scorpis aequipinnis* Richardson, and *Rhycherus filamentosus* (Castelnau).

4. *Parascyllium multimaculatum*, sp. nov. (family Hemiscylliidae) is described and figured.

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Explanation of Plate

Plate V—

Fig. 1.—*Parascyllium multimaculatum*, sp. nov. Holotype. Male. Locality, Tamar Heads, Tasmania. Total length 710 mm.

Fig. 2.—*Rhycherus filamentosus* (Castelnau). Locality, Tamar Heads, Tasmania. Total length, 216 mm.

Fig. 1.

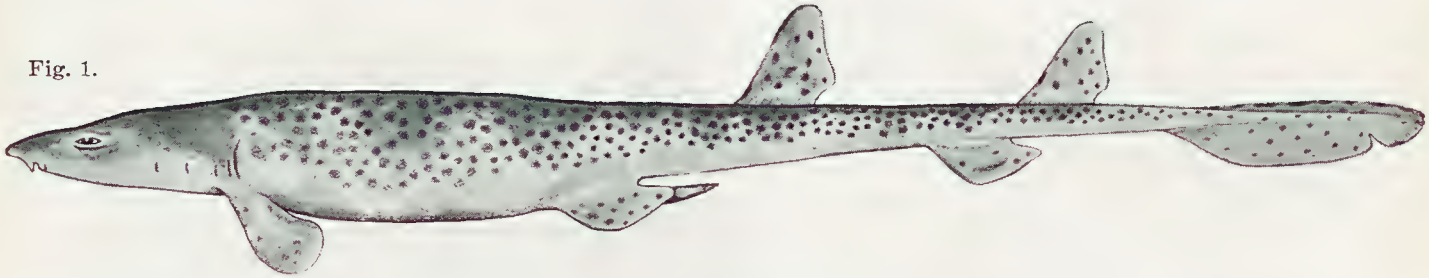

Fig. 2.

Fig. 1.—*Parascyllium multimaculatum*, sp. nov.

Fig. 2.—*Rhycherus filamentosus* (Castelnau) [E.O.G.S. del.] [Burrows photo.

Correlation of the Tasmanian Pleistocene Raised Beaches and River Terraces in Unglaciated Areas

By

A. N. Lewis, M.C., LL.D.

Two Plates and Three Text Figures

(Read 12th November, 1934)

This paper follows my attempted correlation of the Pleistocene glacial epochs (Lewis, 1934).

Further study of the raised beaches and river terraces in the Derwent, Coal, and Huon River valleys has made possible a tentative statement of the late Tertiary and Pleistocene succession in Southern Tasmania. The whole problem has by no means been solved, but sufficient data are forthcoming to warrant recording as a basis for future work. This is the phase of Tasmanian geology which has received the least attention in the past, and it was not until the effect of the waxing and waning of the four Pleistocene Ice Sheets on the level of the ocean was fully understood that the various apparently contradictory features of our coastal plains was decipherable.

The facts stated in this paper are entirely based on physiographic evidence. Certain palaeontological evidence is forthcoming from Northern Tasmania, and some information as to past happenings may be discoverable from a study of the petrological groupings of the pebbles in the various drifts, but no key in either direction has yet been found in Southern Tasmania. The association between the *Mirnyongs* (native kitchen middens) and the physiographic succession of river and marine terraces opens up an interesting field which has not yet been explored. This paper is intended to supply the geological background for further work by the anthropologist in this direction.

The remarkably accurate and detailed description of general post-Tertiary geology given by R. M. Johnston (1888) can hardly be amplified. W. H. Twelvetrees (1909) carried our knowledge very little further, and fully confirmed Johnston's general conclusions. Our present Government Geologist, Mr. P. B. Nye (1924) has given us the best general account of the geology of part of the area under discussion in this paper. He has divided the more recent sediments into Lower and Upper Tertiary, using the eruptive flows of olivine basalt as the dividing line. My observations confirm what Mr. Nye has written, except that it is quite possible that the whole of

the Tertiary deposits he describes are Upper Tertiary (Pliocene). The division, however, is clear. The basalt appears to be referable to the more recent or upper basalt flows, and the date may not be further back than the opening of the Pleistocene period. Deposition of river gravels appears to have preceded the basaltic eruptions and to have continued, almost uninterruptedly, after the volcanic phase. All this, however, is open to some doubt at present, and in the present paper I start with the physiography as it appears after the last orogenic movements and the probably accompanying volcanic phase had ceased.

Succession of Tertiary and Pleistocene Rocks in Southern Tasmania

(*a*) Leaf beds at One Tree Point, Pipeclay Bluff, and Geilston Bay, with river drift conglomerates and sandstones undifferentiated *inter se*. (Lower Tertiary of Nye.)

(*b*)—(i) Nephelite-Basanite of One Tree Point.

(ii) An eroded, unidentified porphyry-like rock at One Mile Hill, east of Bellerive.

(iii) Olivine basalts that occur in isolated patches at intervals seldom exceeding a mile along the valleys.

The above appears to be the sequence of this series. Perhaps the two first named represent the lower basalts and the last the upper basalts; perhaps some of the river drifts accumulated between these eruptions; but no evidence is as yet forthcoming on these points. The conglomerates that fringe Mt. Nelson appear to be river deposits brought from a distance. At One Tree Point they are overlain by Nephelite-Basanite.

(*c*) Newer conglomerates of immediately pre-Malannan age overlying the basalts and covering the old floors of the valleys to a height of 50-100 feet above present sea-level. The best occurrence of these is at Millbrook Rise, New Norfolk.

(*d*) Malanna phase, represented by river erosion to a depth of 150 feet below present sea-level in entrenched meanders.

(*e*) Malanna-Yolande interglacial phase, represented by the silting up of the Malannan troughs in the main and tributary valleys to a height of 50 feet above present sea-level, with raised beaches, inland wave terraces, and sand dunes and secondary river terraces in places.

(*f*) Yolande phase, represented by river erosion to a depth of 60 feet below present sea-level and the erosion of the present river channels, again in entrenched meanders.

(*g*) Yolande-Margaret interglacial phase, represented by a third series of terraces, raised beaches, etc., 5-15 feet above present sea-level.

(*h*) Margaret phase, during which the existing river courses were eroded. Data as to the depth to which the main channels were cut in the Yolande-Margaret silts is not forthcoming, but many tributary valleys were deepened 10-25 feet in the most recent delta and terrace silts.

(*i*) Post Margaret phase, represented by a progressive rise in sea-level, resulting in the silting up again of estuaries and bays and the drowning of certain lower tributaries.

All search in this area fails to disclose evidence of the missing fourth glacial phase. I still regard it as possible that land movements during the early Pleistocene have obscured records of such a phase here as well as in the glaciated areas. Otherwise, Southern Tasmania appears to have been a stable area since Malannan times.

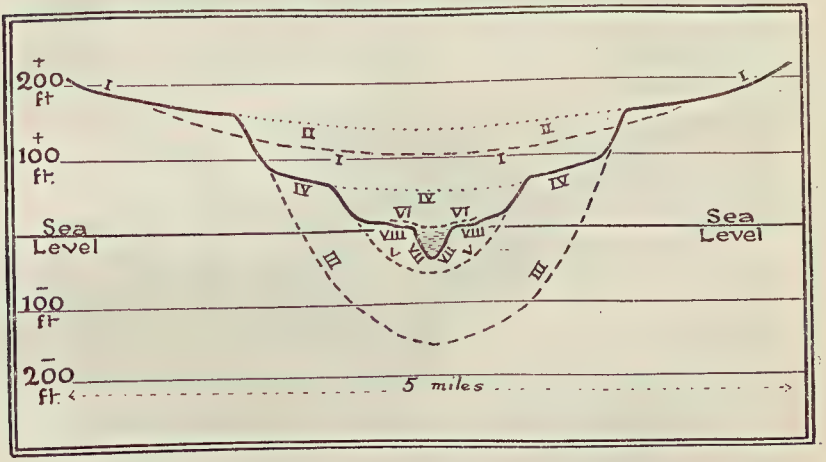

Fig. 1.—Generalized diagram, adapted from Derwent Valley features, illustrating comparative movements of strand-level with erosion and deposition features.

I—Late Tertiary valley.
II—Pre-Malannan silts.
III—Malannan trough.
IV—Malannan-Yolande silts.
V—Yolande trough.
VI—Yolande-Margaret silts.
VII—Margaret trough.
VIII—Post-Margaret silts.

The Derwent Valley

The pre-Malannan valley floor may be traced by remnants of consolidated clays, sands, and conglomerates standing at the fairly regular height of 50-100 feet above present sea-level. These are marked by the predominance of pebbles of quartzite and early Palaeozoic rocks, with an almost entire absence of dolerite pebbles. They are to be seen at Millbrook Rise, just below New Norfolk, and at several points on the northern bank of the river between the Rocks and Dromedary. They cap basalt flows between Bridgewater and Herds-

man's Cove, and are to be found about a mile east of Old Beach post-office. They occur at Claremont, Glenorchy, and Lindisfarne. The regularity, both petrographically and physiographically, of these remnants indicates that they were once part of a continuous plain. They could not have been deposited under existing conditions.

The river, evidently flowing in gentle curving meanders, cut into these deposits to a depth of about 200 feet, as is shown by borings at Risdon and Cornelian Point. (See Journals and Papers of Parliament, Vol. CXIX, No. 2, and Text figs. 3 and 4.) It would be impossible for this trough to have been eroded as it is to a depth of 150 feet below sea-level unless the strand line had dropped to this extent. The information supplied by these bores is conclusive. The general physiography of the valley indicates that the trough was eroded

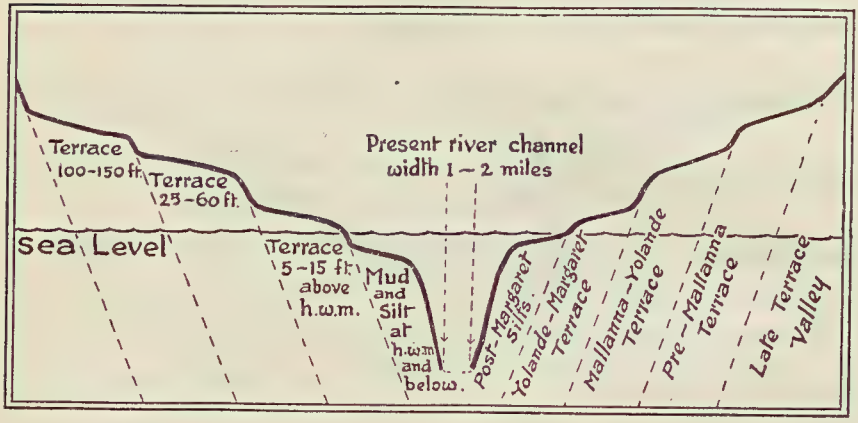

Fig. 2.—Diagram showing succession of terraces and periods of deposition.

subsequently to the deposits here termed pre-Malannan. It was probably at this period that the otherwise strange cliffs at the Rocks and Bedlam Walls were formed. The river clearly entrenched itself in pre-existing meanders in no clear relationship to the present minor details of the valley topography. Tributary valleys show a corresponding deepening—particularly the larger ones, such as the Lachlan and Jordan.

The subsequent rise of strand-level produced newer river conglomerates, which outcrop along the road from Granton to New Norfolk and elsewhere on both sides of the Derwent. Tributary valleys were drowned to a height of 30 feet or so, and deltas were formed in them. This newer conglomerate consists almost entirely of dolerite and Permo-Carboniferous mudstone pebbles. In some places it is clearly hill wash and the product of small hill streams, but is roughly stratified at a height well above where it could lodge under present conditions. In the majority of localities, however, the evidence

of well-worn pebbles and a considerable degree of stratification points to a deposition by the main river of materials brought from a considerable distance. These deposits have often been considerably eroded, and sometimes stand as the divide between more modern stream courses. The Malannan trough largely (perhaps entirely) silted up during this phase.

The next phase corresponds with the Yolande glaciation. The actual river valley during this phase is now submerged, and data are difficult to obtain, but the erosion of the deposits referable to the previous high-water phase was effected at this time, resulting in the many raised bluffs round which the road from Granton to New Norfolk winds. It also appears to me that the river channel was eroded to a depth of 30-60 feet below present sea-level. This formed virtually the present estuary, on the sides of which the subsequent terraces were deposited.

The Yolande-Margaret interglacial phase gave us the very distinct terraces standing now from high-water mark to 15 feet above high-water mark. The road from Granton to Sorell Creek winds along this terrace, and it is very noticeable under the Rocks where it is followed by the railway. It appears on both sides of Sorell Creek as a distinct separate terrace, and may be traced round the shore of most of the Derwent estuary, noticeably under Bedlam Walls, the cliffs at Lindisfarne, the Bluff at Bellerive, and the cliffs below the Shot Tower. Probably at this time the waters of the estuary extended to the obvious raised shore lines at the heads of several bays, notably at Kingston, where they extended inland to the present road bridge, and at Risdon Cove, where they extended to the old stone bridge or thereabouts.

The features imparted by the Margaret glacial phase of low water are also difficult to decipher except in tributary streams, but from Sorell Creek to the Iron Pot there is a definite old river channel meandering through the drowned estuary floor, a distinct river course to the vicinity of Hobart and then widening out. Its average depth below the general floor of the estuary is 20 feet. It is probably the result of erosion during this period. Throughout the area all streams have cut deep, straight-sided channels some 10 feet deep, or a little more in the newest terraces. This is such a uniform feature, particularly where the Yolande-Margaret terraces are well marked, that it must be due to more than local influences. The small entrenched meanders of such tributaries as the Lachlan, Sorell Creek, Risdon Creek, Kangaroo Rivulet, Rokeby Creek, and Brown's River, through their estuarine deltas of Yolande-Margaret interglacial age, provide the best examples, and the same feature may be seen in every creek and mountain stream through the area.

The last phase has been the steady drowning of the Derwent estuary and the mouths of its tributaries up to New Norfolk. This has resulted in a progressive silting in the course of the main river

above Bridgewater and in the bays below. This silting is quite distinguishable from the previously formed terraces, which it continues but at a slightly lower level.

Two further features deserve passing mention. Across the estuary at its mouth westward from the Iron Pot is a marked bar. This appears to me to be, most probably, the flooded and eroded continua-

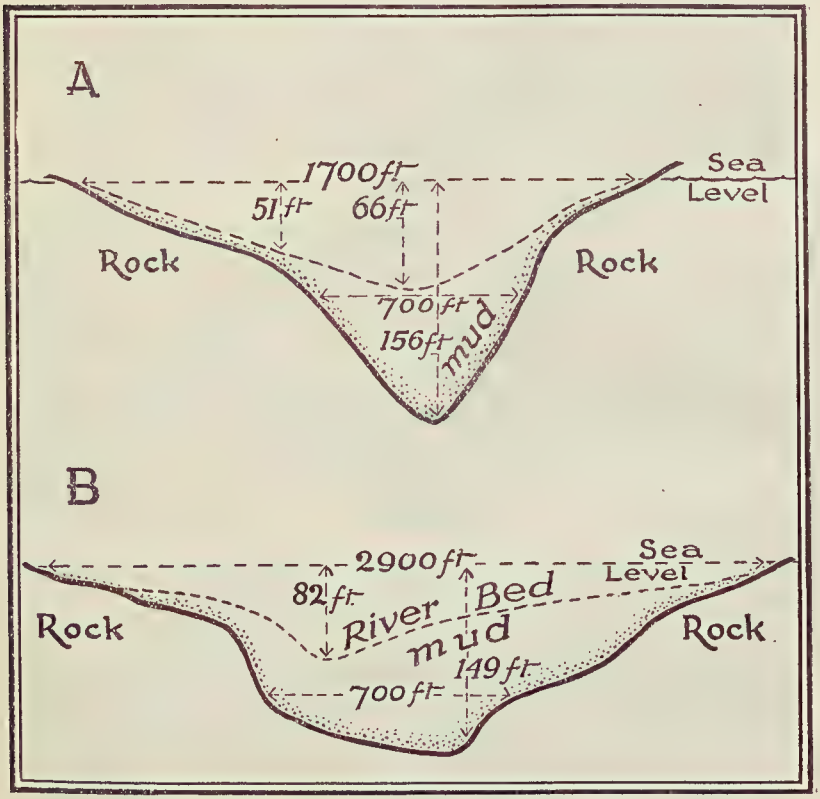

Fig. 3.—Sections through Derwent River (after diagrams in Journ. & Pap. Parlt. Tas. CXIX, No. 2).
A.—at Risdon. B.—at Cornelian Point.

tion of the line of sand dunes that may now be seen forming the connexion between the Sandford Peninsula and South Arm. It seems likely that during the maximum low-water phase of the Malanna period this was the real mouth of the river, and here sea-blown sand dunes accumulated as a bar. Perhaps the bar was complete with the waters of the Derwent passing down D'Entrecasteaux Channel. A

second bar extends from Long Point to the beaches at Bellerive. Long Point is the residual of a line of sand dunes that probably marked the mouth of the river during the Yolande period of low water.

The Coal River - Pittwater Valley

A similar series of features can be traced in this area. The older Tertiary deposits can be seen underlying basalt flows in the valley of the Coal just above Richmond. The pre-Malanna land surface stands at the height of the eroded basalt and over-lying gravels, about 50-100 feet above present sea-level. Subsequent events during the low-water periods are somewhat obscured by the fact that the Coal River does not appear to have eroded to the lowest sea-level, probably owing to its limited flow. During the Malanna phase the mouth of the river was probably in the vicinity of Lewisham, and the extensive sand-dune deposits of some antiquity that form the Milford Peninsula may be referable to this phase. The Coal River cut a considerable channel to an unknown depth south of Richmond, and it, with its tributaries, cut the channel through the present Pittwater. The effects of the second and third periods of high water are clearly decipherable in the double sets of terraces which occur throughout the river valley for several miles above and below Richmond. One, probably the Malanna-Yolande interglacial, was responsible for true raised beaches, which cover Milford, and may now be seen to a height of 20 feet or more on the road to the pine plantations and to a height of 10 feet surrounding Baralla Bay, and also for the line of old sand dunes that extend to the point terminated by Billy's Island, at the present mouth of the Coal River. Seven Mile Beach is a dune formation of new sand blown over older raised beach deposits at the mouth of the river as it stood during the lower water phases. Pittwater is the area of flooded river flats behind the line of dunes marking the true sea-board. The silting of the river mouths consequent on the latest rise in strand-level is most noticeable.

The Huon Valley

In this area older Tertiary deposits of white quartzite gravels and conglomerates are well developed, principally at Huonville and Castle Forbes Bay, where they occur several hundred feet above sea-level. At Ranelagh wharf they outcrop under newer basalt. This basalt appears to have been eroded no lower than 50 feet above present sea-level. The same sequence of newer terraces is discernible—particularly for several miles along the Cygnet-road near Woodstock. The first of the series formed the fertile flats now 5-15 feet above river-level and, probably, Egg Island. The third series can be seen again as more recent silts. As with the other valleys, the successive troughs are difficult to ascertain, but appear to follow a similar succession as those in the Derwent Valley.

The North Coast

R. M. Johnston (1888) has given us the best account of this area yet published. He notes (p. 326) raised beaches, subordinate valleys within the main ones, river terraces, hillocks of consolidated sand dunes, and the oscillation of the strand-level. He records raised beaches at 100 feet above sea-level on Chappell Island (Furneaux Group). The Helicidae Sandstone group, a marine deposit standing at 100 feet above present sea-level on nearly all the islands of Bass Strait, may be definitely correlated with the pre-Malannan deposits of Southern Tasmania. This appears to represent the period of high water that initiated the Pleistocene age. The clay pan deposits underlying the Mowbray and other swamps of the extreme north-west coast, and which are, in places at any rate, composed of compacted deposits of calcareous marine worm-tubes, are also referable to the same period. Similar rocks are common on the Victorian and South Australian coasts.

The succeeding Malanna glacial phase must have left exposed a land bridge between Tasmania and Victoria even if there has been no subsequent subsidence. Johnston notes, although he did not identify, the next or Malanna-Yolande interglacial raised beaches. He states that they are invariably 40-50 feet above the present sea-level, and sometimes extend for a mile inland. To the same phase is referable the marked shore platform that skirts the whole of the north-west coast almost without a break. The towns of Ulverstone, Penguin, and Burnie are built on this platform, and it may be seen very clearly when standing on any coastal eminence. This is merely a wave-cut platform in the localities where spurs jut northward, but in the lower localities, as at Ulverstone and at the mouths of the Forth and Emu, fine sections of stratified conglomerates and raised beaches are exposed.

The final high-water phase (Yolande-Margaret inter-glacial) gave a second terrace, now standing a few feet above high-water mark. This is most noticeable from the Don to some miles westward of the Forth, but it may also be seen in many places round the coast.

The river valleys display terrace features with a general similarity to those in Southern Tasmania. The only published description bearing on this topic is to be found in Sir Edgeworth David's inaugural R. M. Johnston Lecture (David, 1924). The observations therein reported correspond very closely with those I have recorded in this paper from the Derwent Valley. In the next section I mention grounds for supposing a negative movement of the Bassian isthmus since Yolande-Margaret times. This movement is not apparent on the immediate sea-board, although it is reflected in the river valleys.

The Antiquity of Man in Tasmania

The segregation of the Pleistocene deposits as stated above provides us with a key to the problem as to the date of the arrival of the Tasmanian aborigines in the island. At present I am not in a position to give a final answer to this problem, and the present paper is intended merely as a starting point for investigations in this direction. In the first place, I think it must be accepted that the race emigrated by a more or less dry-land Bassian bridge. They may have been a preserved residual of a race which had previously spread all over the continent, or they may have been driven across by the superior Australian races. Their condition as described by actual observers indicates that the race was decadent, and they may originally have been able to build better rafts that those seen by the early explorers. Even so, it is very difficult to imagine a primitive people setting out for a land which lay over the horizon, and of the existence of which they must have been entirely ignorant. If they came by boats at all, the strand-line must have been sufficiently lower than it is at present to have allowed them to see the next land ahead, and their boats must have sufficed to have carried a sufficient number of people to maintain the race. From every point of view, the emigration must have occurred when Bass Strait was very different from what it is to-day.

It is clear that the strand-line dropped some 150 feet (25 fathoms) during Malannan times, some 50-60 feet (10 fathoms) during Yolande times, and some 10-25 feet during Margaret times (2-4 fathoms). Reference to the diagrams given by Dr. Fitz Noetling (1911, Plate I) shows that if the Bassian segment has remained at the level at which we see it at the present time, a sufficient land bridge could have only existed during Malannan times, and the subsequent glacial phases would not have lowered the surface of the ocean sufficiently to affect the position materially.

The absence of traces of the fourth ice phase constitutes a difficulty here, but the Malannan phase, which is probably to be correlated with the Mindel of the northern hemisphere or the Ross-Mindel interglacial, cannot be later than the Mindel. The Tasmanian people were a Negrito stock. It seems to be out of the question to suppose that members of this race could have penetrated to Southern Australia in Mindel times. (See Griffith Taylor, 1921, Plate I.) Should this prove to have been the case, it would present a remarkable case of homotaxis, it would indicate the way in which the aborigines crossed to Tasmania, and it would prove that the Bassian isthmus has been stable since Malannan times.

It is necessary to search elsewhere for evidence. As far as I have been able to see, the earliest mirnyongs lie on the raised beaches of the Yolande-Margaret interglacial period. Those I tentatively correlate with the Ross-Worm interglacial stage. It appears to me to be clear from the erosion below present sea-level of many of the

coastal mirnyongs that some of these accumulated prior to the Margaret (Worm) glaciation. A very significant one may be seen on the New Norfolk road near the 13th milstone, and a repetition or continuation on the Bridgewater-Dromedary road a couple of miles from Bridgewater. These consist of shells of open-sea forms. Such molluscs could not exist in the estuary in its present form. They must have been gathered near where they are at present to be seen. They rest on the Yolande-Margaret terrace and are overlain by many feet of soil. It appears to me that the interglacial phases must have been accompanied by dry conditions, resulting in very little fresh water flowing into the estuary. The post-Margaret silts which now fringe the river could not then have existed. The water-level must have been somewhat higher, and the combination of all these factors resulted in a degree of salinity, even above Bridgewater, equal to that in the bays of the open coast. I consider these particular shell middens to have been eroded during the succeeding lower-water phase.

That would place this particular mirnyong in the Yolande-Margaret (Ross-Worm) interglacial phase, and this date corresponds with Griffith Taylor's for the emigration of the Tasmanians into Australia. It also corresponds with the age of the Talgai skull and the Doone flint (David, 1924). Estimates of time differ so greatly amongst various writers that it is difficult to give more than an approximation. Griffith Taylor would put the date, as far as our present knowledge goes, at which the aborigines accumulated the earliest mirnyongs that I have been able to identify at 200,000 years ago (Taylor, 1921). David makes this possibly 150,000 years, and Coleman would appear to date it as a somewhat more recent time in the neighbourhood of 100,000 years (Coleman, 1926). It does not appear to have been possibly later than the latter figure, extraordinary as this may seem.

To date, no shell mounds or flaked stones have been found earlier than the Yolande-Margaret interglacial terraces. The lowering of the sea-level during either the Yolande or the Margaret glacial phases could not have produced a land bridge to Victoria. That being so, the conclusion must be that there has been a negative eustatic movement of the Bassian isthmus since the aborigines emigrated to Tasmania. The evidence points to the fact that they migrated southward during a warm dry period. This indicates the possibility that the driving force may have been climatic, i.e., the southward movement of the central Australian desert belt, with the aborigines following the game which moved with the forest belts. It may have been a desert barrier which divided these people from the dingo-taming Australian races. All the evidence at present to hand therefore points to the separation of Tasmania, subsequent to the arrival of the aborigines, by earth movements across the Bassian land bridge which led to its eventual flooding. This trapped

the aborigines here during the Margaret ice age. It is probable that at the time of their advent the fauna was somewhat different and more plentiful, and the rigorous conditions of the last phase of the ice age resulted in a steady deterioration of the race.

The gelogical evidence all points to a recent slight sinking or sagging of the Bassian terrain. It is a recognised modern earthquake zone, from which minor tremors are frequently reported. Also, the very marked rejuvenation of the rivers emptying into the Strait points to a recent subsidence rather than a post-glacial flooding. The problem of the date of the advent of the aborigines into Tasmania is so intimately connected with the problem of the formation of Bass Strait that the two must be studied together.

Future Study

I have not been able to give close attention to more than a small fraction of river valleys and coastal estuaries which provide so rich a terrain for the study of these problems. We have a number of ardent anthropologists who devote much energy to the collection of worked stones from sand blows and middens. I hope I have opened up a new avenue for these workers, and I commend the devotion of some attention to the succession of Pleistocene terraces wherever they occur. A study of the relationship of these terraces to the mirnyongs, to ascertain the lowest gelogical horizon at which human life occurred, must prove more fruitful than the mere collection of specimens of culture, in themselves very uniform. Shell mounds are more likely to produce a key than isolated flints which may have become displaced, but all pebble drifts and terraces should be diligently searched for artifacts, as a vital clue may be found, as in the case of the Doone flint. The shell mounds themselves may be correlated to the phases of the Pleistocene period, and some change in culture may be traced when this correlation has been made. I have said sufficient to indicate a new field for anthropological study.

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Explanation of Plates

PLATE VI—

Fig. 1.—Derwent Valley below Sorell Creek. Photo taken from site of pre-Malanna terrace. The second (Malanna-Yolande interglacial) series is visible as the cleared paddock beyond the tree and road in the foreground and by the point beyond the river on left of picture.

The third (Yolande-Margaret interglacial) series is visible as the river flats bordering the river. At this point the river is now affected by tidal influences. Post-Margaret silts line the river below H.W.M., and an old channel 30 feet deep winds through these.

Fig. 2.—Terraces at Burnie, on the North Coast.

The hills in the background represent the old shore-line. The town of Wivenhoe is built on a second terrace, a section of which can be seen at the Emu Bridge in the right centre. A third terrace is visible to the seaward of this in the foreground and also at the termination of the point in the distance.

PLATE VII—Terraces in a tributary valley of the Derwent.

Fig. 1.—In the Lachlan Valley. The Millbrook Rise terrace can be seen under the farm buildings in the left middle distance. The next terrace formed by the silting up of the valley excavated in the Millbrook Rise terrace may be seen in the foreground. The present river has cut a channel in this, as seen in the foreground. The estuary of this channel ¼-mile below where photo taken has now been partly silted up.

Fig. 2.—Typical valley of tributary hill stream. The channel has been cut in the second (Malanna-Yolande) terrace, seen on the sides of the valley. The valley so excavated has been resilted up. In most cases this has again been dissected by recent streams.

[*A. N. Lewis Photo.*

Fig. 1.—Derwent Valley below Sorell Creek.

[*A. N. Lewis Photo.*

Fig. 2.—Terraces at Burnie, N.W. Coast, Tasmania.

Fig. 1.—Lachlan Valley, New Norfolk. [*A. N. Lewis Photo*

Fig. 2.—Silted Tributary Valley. [*A. N. Lewis Photo*

Glacial Features in the D'Entrecasteaux Valley

By

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and

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In 1928 (Lewis, 1928) one of the present authors reported Silurian quartzite conglomerates in the valley of the D'Entrecasteaux River—Recherche Bay area—South-Western Tasmania. In so doing he was influenced by Twelvetrees (1915). Considering the matter more recently, it appeared that this occurrence might be of glacial origin. If this proved to be correct, the original site of these rocks must be westward of the La Perouse Range. An opportunity to visit this difficult locality has now presented itself. The rocks in question are undoubtedly of glacial origin, but they are Triassic grits, and not of Silurian age. No one can now be sure whether the series is the same as that reported by Twelvetrees, but from his very brief description this may be so. In any case, some further observations were made which are worth recording. This paper must be considered merely as an amplification of the previous account (Lewis, 1928).

Some four miles westward of Leprena, in the D'Entrecasteaux valley, and some two miles westward of the seaward limit of the button-grass plain in that locality, a peculiar button-grass covered and stream dissected spur runs northward from Leillateah to the present course of the river. This was previously described as consisting of quartzite conglomerate boulders (Lewis, 1928, p. 193). It is, in fact, an old moraine. On the surface lie boulders of considerable size. These consist of coarse quartzite conglomerates and grits, but of Triassic age, and evidently derived from the flanks of La Perouse, where a thin band of similar rocks exists (Lewis, 1924, p. 23). This spur is a distinctive feature, clearly discernible for miles around. The large white boulders are merely the largest erratics left on the surface after the finer and softer material has been washed away. The evidence that this is really an old moraine is—

(1) The assorted nature of the rocks, which are a jumble of stones of all sizes, from sand to the size of a large tent, and of conglomerates, grits, sandstones, shales of Triassic age, fossiliferous mudstones of Permo-Carboniferous age, and dolerite.

(2) The stratification planes of the grits, which are clearly visible, now appear pointing to every point of the compass and at every angle.

(3) The grits when *in situ* only occupy a vertical range of 50-100 feet, while here they are strewn over a vertical height of nearly 1000 feet.

(4) The ridge extends into the main valley in such a way that it cannot be an erosion feature, and is dissected by streams that traverse its long axis in a way which shows that they cannot have been responsible for it.

(5) The degree of dissection compared with that of the neighbouring hillsides shows that it is of different topographic origin from the main valley.

(6) The rubbly nature can be seen over a vertical range of nearly 1000 feet. We see here a very considerable ancient moraine lying across a previously eroded glacial valley, and itself eroded by a newer glacier which has superimposed its moraine upon the older one in rather a peculiar manner.

The whole D'Entrecasteaux valley appears to have been filled with ice at some time. It could not have been eroded as we see it at present by the existing river; its spurs have been shorn by a glacier, and there is evidence that ice reached sea-level at Leprena, where quartz pebbles and basalt boulders indicate an eroded moraine. Subsequently, a glacier deposited the moraine already described as a barrier across the valley. This may originally have stood 800-1000 feet above the valley floor. This moraine was then eroded to about 400 feet above sea-level on the northern side of the valley, and ice again extended to at least the eastern extremity of the button-grass plain, some two miles below the old moraine, and deposited a newer moraine in the valley occupied by it. Subsequently again, ice invaded the highlands of La Perouse, two miles further westward, and gave us the mountain tarns already fully described (Lewis, 1924). The lastmentioned glaciers did not reach the Leprena Plain. The glacier which flowed down the valley eroded in the older moraine reached at least to 300 feet above sea-level, but did not fill the valley as previously eroded. In its own valley it left a considerable area of terminal moraine, now visible as the button-grass plain of the D'Entrecasteaux valley, and distinguished by frequent small boulders of dolerite, particularly where clumps of trees are now growing.

This is the first recorded instance of a Pleistocene moraine definitely superimposed on an earlier moraine of the same period. The appearance of this feature, however, is very different from what was expected. We see here a Pleistocene moraine which must at one time have formed a wall some 800-1000 feet high and about a

mile broad across a valley which had previously been impressed with typically glacial characteristics. After the disappearance of the ice which deposited this moraine, it was breached at one side, and eroded below the present level of the valley floor. During a succeeding glacial phase of the Pleistocene period a new glacier passed through this breach, widening it considerably, and, eventually, deposited its terminal moraine for four miles or more over its valley. This material is of unknown depth, but it must be shallow in comparison to the huge older moraine. It extends along the present valley both below and above the older moraine, and is definitely superimposed on the old transverse deposit where it crosses it.

The sequence of events during the Pleistocene ice age appears to have been as follows. The period was initiated before the final uplift of the La Perouse Range when the area was a dissected peneplain, with Leillateah and Sugar Loaf Range representing the general level of the higher elevations. The summits of La Perouse, Pindar's Peak, Mts. Wyllie, &c., and Precipitous Bluff group probably stood at much the same general level (2500 feet). During the first discernible glacial phase (Malanna) an ice-cap covered the plateau, and extended in very considerable glaciers to sea-level down the D'Entrecasteaux, Catamaran, and Lune valleys. The terminal areas of the glaciers are now flooded. Ice must have been over 1000 feet in depth, and must have entirely filled the valleys. During the recession of the glacier in the D'Entrecasteaux valley the transverse grit moraine was deposited. The uplift of the La Perouse group of mountains to their present height (4000 feet) occurred during the succeeding (Malanna-Yolande) interglacial phase. At this time the streams flowing over the new escarpment wore the present gorges and deepened troughs in the older glacial valleys. The Yolande glaciers succeeded, and were responsible for the cirques described by Lewis (1924). The Margaret phase was responsible for the mountain tarns and superimposed cirques also described in the lastmentioned paper.

Two other possibilities exist, but the evidence is too doubtful to permit of either being advanced as certainties until confirmed by observations elsewhere. The transverse grit moraine has definitely been deposited in a previously eroded glacial valley. This erosion may have been due to the same glacier as deposited the moraine, that event having occurred towards the end of its recession phase. On the other hand, we may have here evidence of two separate glacial phases. The second possibility is that the glacier which was responsible for the superimposed moraine descended, not from the cirques at present so clearly defined on the sides of La Perouse, but from a point half-way down the three valleys of the present D'Entrecasteaux River. Here there is now a marked topographical break, a sharp waterworn gorge indicating a drop of about 1000 feet with the

glaciated valley below and the cirques and glaciated valleys above. This feature may indicate two glacial phases between that responsible for the transverse grit moraine and the Margaret features on the mountain tops. Lewis (1924, Plate VI. fig. 1) shows a view from the top of the Yolande cirque, with the glacial valley extending towards Leillateah in the centre of the picture. At that point the valley turns half left and drops rapidly. 1000 feet below are found the traces of the glacier which was responsible for the superimposed moraine. (In the same paper Plate VI, fig. 2, shows a Margaret cirque superimposed on the Yolande cirque shown in fig. 1, the edge of which is visible on the left of fig. 2.) The break in the glacial valleys as here described may be due to post-glacial (or post-Yolande) river erosion at the point which the streams fall over the main fault scarp of the range, or it may represent the scarp of a post-Yolande uplift breaking the continuity of the Yolande glacial valley, or it may represent the results of two distinct ice phases.

It appears, therefore, that this area shows a topography which would well conform to a landscape moulded by four distinct Pleistocene glaciations. But at present we do not regard the evidence so far available as conclusive proof of the existence in this part of Tasmania of four Pleistocene glacial periods, and confirmation must still be sought elsewhere. The evidence in the D'Entrecasteaux valley is quite consistent with the occurrence of only three glacial phases. For the present we assign to the transverse grit moraine the tentative appellation of " The D'Entrecasteaux Phase," leaving it to future investigation to determine whether it should be correlated with the Malanna glacial phase or whether it represents the missing fourth glaciation.

References.

Twelvetrees, W. H. 1915—The Catamaran, etc., Coal Fields. *Geol. Survey Tas. Bul.* No. 20.

Lewis, A. N. 1925—Notes on a Geological Reconnaissance of Mt. La Perouse Range. *P. & P. Roy. Soc. Tas.* 1924 (1925), p. 9.

———— 1928—A further account of the Geology of the Catamaran Coal Field. *P. & P. Roy. Soc. Tas.* 1927 (1928), p. 188.

The Royal Society of Tasmania

Abstract of Proceedings
1934

22ND JANUARY, 1934

A special meeting was held in the Society's Rooms, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

Professor W. A. Osborne, M.B., B.Ch., F.A.C.S., delivered a lecture entitled 'Success and Failure in Animal Design.'

12TH MARCH, 1934

Annual Meeting

The Annual Meeting was held at the Society's Rooms, Tasmanian Museum, on this date, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

Under Rule 3 His Excellency the President nominated the following two Vice-Presidents:—Mr. W. H. Clemes and Mr. E. E. Unwin.

The following were elected as members of the Council for 1934:—Mr. S. Angel, Dr. A. H. Clarke, Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. E. T. Emmett, Mr. V. V. Hickman, Dr. A. N. Lewis, Mr. E. E. Unwin, Dr. F. E. Ward.

Mr. Walter E. Taylor was appointed Hon. Auditor.

The following motion was proposed by Dr. Crowther, seconded by Sir Elliott Lewis, and carried:—

> 'That Rule 17 be amended by deleting the words "not resident in Tasmania" from the first line thereof.'

The following motion was proposed by Dr. Crowther, seconded from the Chair, and carried:—

> 'That in accordance with the recommendation of the Council, and in terms of Rule 41e (5), the Society's Medal be awarded to H. H. Scott, Esq., Curator of the Queen Victoria Museum, Launceston.'

The following members were elected:—Col. J. L. Whitham, Mr. Donald Martin.

Mr. S. W. Steane gave an illustrated lecture on 'Bush Fires.'

9TH APRIL, 1934

A meeting was held in the Society's Rooms, Mr. W. H. Clemes presiding.

The Chairman reported that the Council had made the following appointments for the year:—

Chairman: Mr. W. H. Clemes.

Secretary: Dr. Joseph Pearson.

Treasurer: Mr. S. Angel.

Trustees of the Museum: Mr. W. H. Clemes, Dr. W. L. Crowther, Mr. S. Angel, Dr. A. N. Lewis, Mr. E. E. Unwin, Mr. V. V. Hickman.

It was proposed by Dr. Lewis, seconded by Dr. Crowther, and carried, that Mr. L. Rodway be elected an Honorary Member of the Society under Rule 17.

The following members were elected:—Mrs. Clive Lord, Mr. C. E. H. Ferguson, Mr. N. Oldham.

The Chairman presented the Royal Society's Medal to Mr. H. H. Scott. Mr. Unwin, Dr. Crowther, and Mr. Hickman testified to the valuable work which Mr. Scott had done as Curator of the Queen Victoria Museum, Launceston.

Mr. Scott delivered a lecture entitled:

Part 1: 'Mr. Clive E. Lord, my Collaborator.'
Part 2: 'The Australian Marsupial Titanotheres.'

30TH MAY, 1934

The R. M. Johnston Memorial Meeting was held at the Society's Rooms, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

Mrs. G. O. Smith was elected a member.

His Excellency presented the R. M. Johnston Memorial Medal to Professor W. J. Dakin, Professor of Zoology, University of Sydney, who afterwards delivered the fourth R. M. Johnston Memorial Lecture, entitled 'Biological Science and Marine Fisheries.'

After the lecture a Conversazione was held in the Art Gallery.

11TH JUNE, 1934

A meeting was held in the Society's Rooms, the President, His Excellency Sir Ernest Clark, K.C.B., C.B.E., presiding.

The following members were elected:—Professor K. Shatwell, Mr. R. G. Brett, Mr. R. F. Turner, Mr. D. M. Urquhart, Mr. B. C. Lovett.

Dr. Joseph Pearson delivered an illustrated lecture on 'The Wanderings of Animals.'

9TH JULY, 1934

A meeting was held in the Society's Rooms, the President, His Excellency the Governor, presiding.

The following members were elected:—Mrs. R. I. Courthope, Mr. Charles Wolfhagen, Dr. F. Fay.

Mr. R. W. Legge, Hon. Curator, Ethnological Section, Tasmanian Museum, read a paper entitled 'Notes on some of the principal Aboriginal Camping Grounds and Middens of the East Coast of Tasmania, with remarks upon their Stone-culture and Food-supply,' and showed slides illustrating the paper.

13TH AUGUST, 1934

A meeting was held at the Society's Rooms, the President, His Excellency the Governor, presiding.

Dr. Joseph Pearson gave some notes on *Caperea marginata*, the pygmy right whale.

Mr. John Reynolds delivered an illustrated lecture entitled 'The Anti-Transportation Movement in Tasmania, 1840-1853.'

10TH SEPTEMBER, 1934.

A meeting was held in the Society's Rooms, the President, His Excellency the Governor, presiding.

The following members were elected:—Mrs. M. Roberts, Mrs. L. Wettenhall, Mr. L. A. Triebel.

Dr. A. N. Lewis proposed the following resolution regarding the death of Sir T. W. Edgeworth David:—

> 'The Royal Society of Tasmania records with deep regret the death of Sir T. W. Edgeworth David, K.B.E., C.M.G., D.S.O., D.Sc., B.A., F.R.S., Emeritus Professor of Geology, University of Sydney, and the senior honorary member of this Society, and places on record its appreciation of a long life of outstanding service for science in Australia, and many acts of assistance rendered to this Society.'

The resolution was seconded by Mr. W. H. Clemes and supported by Mr. W. M. Carne, all present signifying their approval by standing. A copy of the resolution was forwarded to Lady David.

Miss J. A. Fletcher delivered an illustrated lecture entitled 'Field Experiences Amongst Some of Our Birds.'

8TH OCTOBER, 1934

A meeting was held in the Society's Rooms, the President, His Excellency the Governor, presiding.

Captain D. Colbron Pearse, M.C., Hon. Curator of the Art Gallery, delivered an ilustrated lecture entitled 'Whither Art?'

12TH NOVEMBER, 1934

A meeting was held in the Society's Rooms, the President, His Excellency the Governor, presiding.

The following members were elected:—Dr. J. Wunderly, Mr. W. Harris.

The following papers were submitted for publication, and referred to the Standing Committee:—

(*a*) 'Correlation of the Tasmanian Pleistocene Raised Beaches and River Terraces in Unglaciated Areas,' by A. N. Lewis, M.C., LL.D.

(*b*) 'On a New Genus of Fishes of the Family Galaxiidae,' by E. O. G. Scott, B.Sc.

(*c*) 'Notes on the Gobies Recorded from Tasmania: with Description of a New Genus,' by E. O. G. Scott, B.Sc.

Mr. E. T. Emmett delivered an illustrated lecture entitled 'Richmond and its History.'

Northern Branch

Annual Report

The Northern Branch experienced a successful year. Monthly meetings were held during the usual session from May to September, inclusive, and the Council met on seven occasions.

With the exception of the August meeting, which took place at the Launceston Technical College, both monthly meetings and Council meetings were held at the Public Library.

2ND MAY, 1934

Annual Meeting

Mr. W. R. Rolph presided. The following were elected as members of the Branch Council for 1934:—Mr. W. R. Rolph (Chairman), Hon. Tasman Shields, Messrs. R. S. Padman, F. Heyward, A. L. Meston, J. E. Heritage, D. V. Allen, F. Smithies, J. R. Forward, E. O. G. Scott (Secretary). The statement of accounts, which disclosed a credit balance of £31 3s. 0d., was read and adopted.

Illustrated lecture: 'Seven Years in the Far East,' by Mr. John A. Brailsford, B.A.

18TH JUNE, 1934

Mr. W. R. Rolph presided. Illustrated lecture: 'Through Trackless Wilds, A Journey from Queenstown to Cradle Mountain *via* Eldon Bluff, Canning Gorge, and Pelion Range,' by Mr. F. Smithies.

16TH JULY, 1934

Mr. W. R. Rolph presided. Illustrated lecture: 'Notes on the Museum Historical Collection,' by Mr. H. H. Scott. Paper: 'On a New Genus of Fishes of the Family Galaxiidae,' by Mr. E. O. G. Scott.

6TH AUGUST, 1934

Mr. A. L. Meston presided. Illustrated lecture: 'Atmospheric Electricity,' by Mr. A. H. Masters.

26TH SEPTEMBER, 1934

Mr. W. R. Rolph presided. Illustrated address, and paper: 'Some Aspects of the Art of Implement-making among the Tasmanian Aboriginals,' by Mr. F. Heyward. Paper: 'Notes on the Gobies Recorded from Tasmania: with Description of a New Genus,' by Mr. E. O. G. Scott.

COUNCIL MEETINGS.

Meetings of the Council were held on 13th April, 28th May, 28th June, 23rd July, 28th August, and 30th September, 1934.

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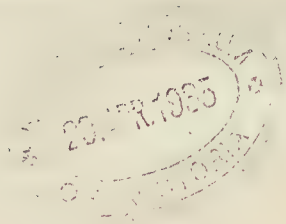

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